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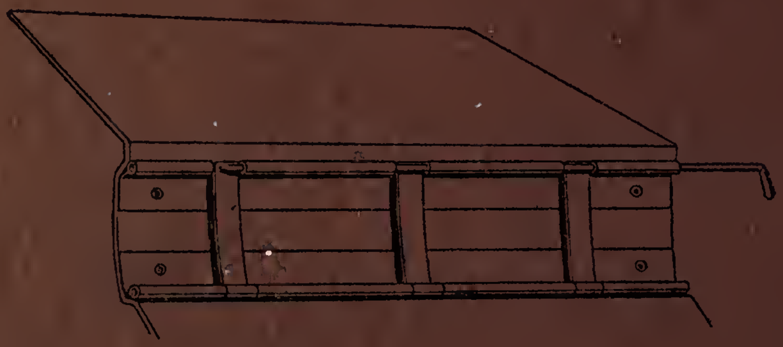

THE TESTICLES AND EPIDIDYMES

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THE TESTICLES AND EPIDIDYMES

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INTRODUCTION

The testes and epididymes are closely related, embryologically and anatomically. The testes arise from the nephrogenic cord along with the mesonephros and its duct (the primary excretory duct) and the müllerian duct. The primary excretory duct becomes the vas deferens, and its accessories become the seminal vesicle and ejaculatory duct, caudally. Cranially it becomes the epididymis, and the few remaining tubules of the mesonephros unite with the tubules of the rete testis to form the urogenital union. The testes are important organs of internal secretion in addition to being the reproductive glands of the male. The epididymes and vasa form the tubular system which carries the sperm to the outside. It is logical, therefore, to consider them together and this is particularly convenient since many diseases primary in the one organ secondarily affect the other.

EMBRYOLOGY

The reproductive organs of both sexes have a very close developmental association. The earliest differentiation occurs in a mass of intermediate cells in the angle between splanchnopleure and somatopleure. This region is known as the urogenital fold and extends the whole length of the cœlom, or primitive abdominal cavity. Later this ridge is split longitudinally into a lateral mesonephric fold and a median genital fold.

In embryos 13 mm. or more in length the indifferent genital fold begins to exhibit within its mass of cells an anastomosing arrangement of cells to form epithelial cords, and between the outer layer of epithelium and these branched cords is the anlage of the tunica albuginea. These two factors of cords and an outer sheath identify the primitive organ as male. The epithelial cords converge toward the mesorchium to form the rete testis and are marked off by sheaths of connective tissue, or septa, which unite toward the rete testis to form the mediastinum testis. The cords of the testis are composed of indifferent cells, interspersed among which are the other larger germ cells. Within the septa the cords of the testis gradually arrange themselves radially (Barry) with respect to the mediastinum testis and establish lumina which connect with the lumina of the mass of indifferent cells, forming the rete testis. The distal portions of the tubules become greatly elongated and convoluted, forming the tubuli contorti, while the proximal portions remain straight as the tubuli recti. After the coiled seminiferous tubules are surrounded by their sheaths of connective tissue they are called coni vasculosi. The rete testis becomes a network of straight tubules which establish open communication with the tubuli collectivi of the genitalis to form the urogenital union, a conjunction of reproductive and excretory structures.

The mesonephros can be observed in embryos from 2.5 to 30 mm. in length. It begins to degenerate from the cephalad end in embryos between 10 and 20 mm. in length. Altogether 83 pairs of tubules form, but in embryos 21 mm. in length only 26 pairs remain. These are divided into an upper group, the epigenitalis, and a lower group, the progenitalis. The upper group forms the tubuli collectivi of the testis (and ovary) and, after the urogenital union, function (in the male) as the ductuli efferentes of the epididymis. The lower group becomes vestigial in both male and female, in the former persisting as the paradidymis and vas aberrans.

Considerably earlier than the gross changes just described, certain large cells have appeared in the caudal end of the body and in an embryo 3.5 mm. in length these cells have begun to migrate by way of the entodermal gut and dorsal mesentery into the epithelium of the genital folds (Politzer, '28). These cells are called primordial germ cells. It has been declared by numerous investigators that the definitive germ cells of the genital glands are descended from them. This contention has been challenged by others, and the literature regarding this interesting problem of the origin of the germ cells has become voluminous. In a recent survey of the literature it was found that the contributors who deal with the origin and history of the definitive germ cells could be divided into four groups (Heys, '31):

1. Those who deny early segregation of germ cells and believe that their formation is a matter of the differentiation of somatic cells.
2. Those who admit early segregation of germ cells but believe that such cells are not definitive. They degenerate and are replaced by proliferations of new cells from the epithelium of the genital fold.
3. Those whose investigations have led to the conclusion that germ cells are segregated early and migrate to the site of the developing gonad to persist as definitive ova or sperm. Their numbers, however, are increased periodically by proliferations from the epithelium of the genital fold.
4. Those who believe that the definitive germ cells are set aside at an early stage in embryonic development, not to be replaced later by transformations of differentiated epithelial cells. Their numbers are increased only by mitotic divisions.

According to Arey ('34), the primordial germ cells of the testicular cords may form the early spermatogonia of the spermatic tubules. He thinks, however, that the later generations probably develop from the so-called indifferent elements which form also the sustentacular (Sertoli) cells of the adult testis. Certain cells of the mesenchymal stroma, which are situated between the testicular cords and give rise to the sheaths of connective tissue, are transformed into large pale cells which become numerous in the interstitial tissue after puberty and are called the interstitial cells, or cells of Leydig.

THE DESCENT OF THE TESTICLE

The exact mechanism of the descent of the testicle is not known, though the gubernaculum has been thought to play an important rôle in normal descent. Recent experimental work in animals, together with the clinical observation that the testes in cryptorchids oftentimes descend following the injection of a suitable dose of a gonadotropic hormone, requires a reconsideration of this phenomenon.

It is known that the testes do not descend in mice and rats until puberty, which suggests the possibility that the male hormone exerts an influence on testicular descent in these animals. Such a view is further strengthened by the knowledge that in certain rodents the testes remain in the abdomen and descend only during the rutting season. It is also known that wide separation of the pubic ligaments, corresponding to that occurring in the pregnant animal, may occur in nonpregnant female guinea pigs after the artificial injection of the normal ovarian hormone (folliculin). Likewise, Burrows recently described the development of scrotal hernia in mice treated with the ovarian hormone (estrin, folliculin, etc.). Kojoma showed that testicular descent does not occur in hypophysectomized immature male animals. Rose observed that after cutting the gubernaculum in experimental animals, the testes descended normally in the majority of cases. It is difficult to reconcile these facts with the view which has been accepted generally heretofore.

Broman showed that, during the seventh month, the gubernaculum not only ceases growth but actually becomes shorter by one half. Since the gubernaculum extends from the caudal pole of each testis through the canal to the scrotal wall, it has been strongly contended that the shortening, both actual and relative, served to force the testes into the scrotum. Such a view, however, is regarded as primitive by Rost, who recently made a study of the descent of the testicle. This author believes that the greatest factor favoring normal descent is the development of increased intra-abdominal pressure. He suggested that the pituitary gland stimulates these organs to growth and increases their size, thereby aiding this mechanism. Many authors, however, after reviewing the available embryological data, frankly declare that the descent of the testicle is entirely a hormonal phenomenon.

Halban, 1904, described changes in the genital organs of new-born infants of both sexes which he attributed to hypothetical hormones secreted by the placenta. Subsequently it was shown by Franke that the female hormone was found in the placenta in high concentrations, and Goldberger ('26) and Aschheim and Zondek ('28) proved that a gonadotropic hormone existed in the placenta and urine.

Engle ('32) showed experimentally that the testes of immature monkeys could be caused to descend by the injection of anterior pituitary extracts obtained from the pituitary glands of sheep, and even more easily by the anterior pituitary-like principle (prolan) obtained from the urine of pregnant women.

The testes uniformly increased to about twice their normal size and weight after suitable dosage of the hormone. The increase chiefly resulted from the growth of tubules and interstitial cells. The scrotal growth was pronounced after injection of the extract from pregnant women's urine.

The labial and scrotal swellings in the human new-born, which subside within a week or so after birth, should be interpreted, in the light of such experimental data on monkeys and other animals, as being caused by at least one of the two hormones known to occur during human pregnancy.

The human female, and probably the great apes, are the only known forms in which this great concentration of gonadokenetic principles exists throughout pregnancy, although the mare has a gonadotropic hormone in the blood during the middle third of pregnancy. In the male it has been shown experimentally that, after treatment with pregnant women's urine, the testis will increase greatly in size while in the inguinal canal and that the mass of interstitial cells will also increase many times above that of the control. The same type and degree of change occur in the human fetus of the eighth and ninth lunar month, during the period when, normally, the descent into the scrotum is completed. This change is found only in man, in whom the testes descend before or at birth. In other animals, in which the inguinal canal remains patent throughout life, testicular descent is associated with the first phases of puberty. In both monkey and man the internal ring is normally closed after the testis enters the canal.

The only known instance of descent at birth is in man, and the only known instance of a gonad-activating principle occurring in the circulation throughout the period of gestation is found in the human female.

Drake has shown that in boys with undescended testicles spontaneous descent occurs most frequently at puberty, at a time when the gonadohormonal relationships are accentuated.

It is possible that several factors contribute to the normal descent of the testicle. Undoubtedly the hormonal factor plays a great rôle. In addition the development of the scrotum and its investing pouches, the gubernaculum, the loosening of the rings of the inguinal canals and the subsequent closing of these rings, the actual and relative growth of the body with that of the testes, and pressure from the outside, as well as increased intra-abdominal pressure, all may exert influences favoring the normal descent of the testicles. It seems probable that many of these factors are so closely interrelated that the predominating influential factor is yet to be determined.

From an embryological viewpoint, the testis is at first a slender structure extending caudalward from the diaphragm. The dorsal trunk elongates cephalad more rapidly than the corresponding growth of the testis, thereby causing a relative shift of the gonads caudalward. About the third month, when this process of growth and shifting is complete, the testes lie in the mid-abdomen and anteriorly. At this time saclike pockets appear in each side of the anterior abdominal wall. From the fourth to the sixth month the testes remain close to these structures. Each processus vaginalis now evaginates through the abdominal wall over the pubis, and through the inguinal canal into the scrotum. In the period from the seventh to the ninth month the testes likewise descend along the same path.

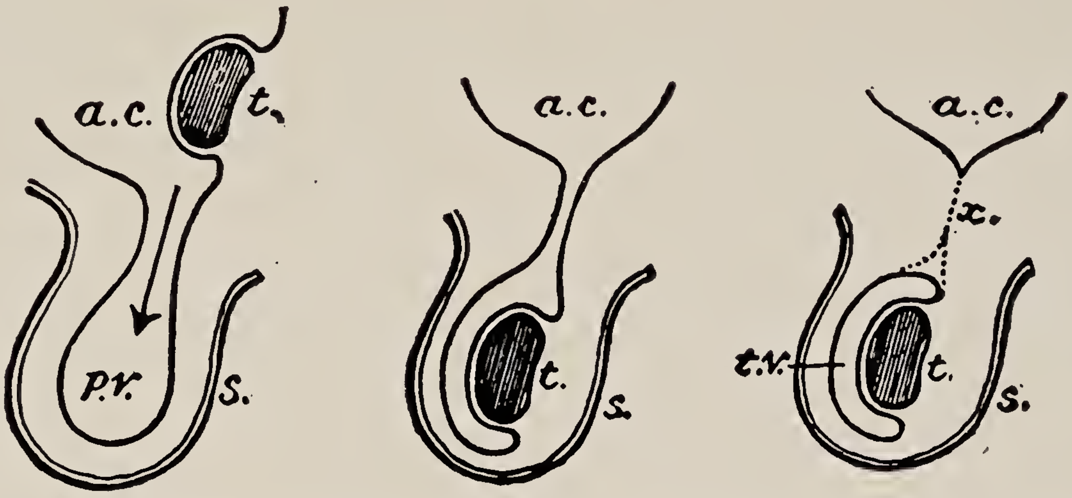

Fig. 1. Diagram illustrating descent of the testis. (Cunningham.) a.c., abdominal cavity; p.v., processus vaginalis; t, testis; s, scrotum; t.v., tunica vaginalis; x, rudiment of processus vaginalis.

After invaginating the processus vaginalis (Fig. 1), the tunica vaginalis of the testis is formed. It consists of a closely applied visceral layer and an outer loose parietal layer. The two layers between the scrotum and the abdominal cavity become fused, forming the funicular process, and the inguinal canal closes, shutting off the open canal between the scrotum and abdomen and precluding the possibility of hernia of the intestines through this canal. The gubernaculum atrophies after the descent of the testicle. The ductus deferens (primitive wolffian duct) and the spermatic vessels and lymphatics are, of course, carried down into the scrotum with the testicle and epididymis. They are surrounded by connective tissue and together constitute the spermatic cord. Owing to the descent of the testis, the ductus deferens is looped over the ureter.

(Fig. 2.) In 30 per cent. of children, the occlusion of the processus vaginalis, forming the funicular process, occurs some time after birth or fails to occur altogether, in which case the process remains open and may form cysts, or hydrocele of the cord.

THE ANATOMY OF THE TESTICLES AND EPIDIDYMES

The testes, or male reproductive glands, are almost symmetrical, oval, greyish-white bodies, measuring about one and a half inches in their greatest dimension, which are situated in the scrotum. They are surrounded by seven enveloping membranes which consist, from within outward, of tunica albuginea, visceral and parietal portions of the tunica vaginalis, the infundibuliform or internal spermatic fascia arising from the transversalis, the cremasteric fascia arising from the internal oblique, and, finally, the scrotal wall itself (dartos and skin). The left gland normally occupies a slightly lower level than the right; varicocele may cause an abnormally low position. The long axis of the testicle is not quite vertically in the scrotum but slightly upward, laterally, and forward. The anterior surface is free. The posterior surface is covered by the epididymis (Figs. 3 and 4) which leads to the spermatic cord by which the testicle is suspended. The relations of the testicle are important, because it is within the tunica vaginalis that the effusion of hydrocele occurs, and, to avoid injury to the epididymis, drainage should be instituted at a point opposite its attachment to the testicle. Here, again, it is important to remember that unilateral inversion may occur as illustrated in Figure 4.

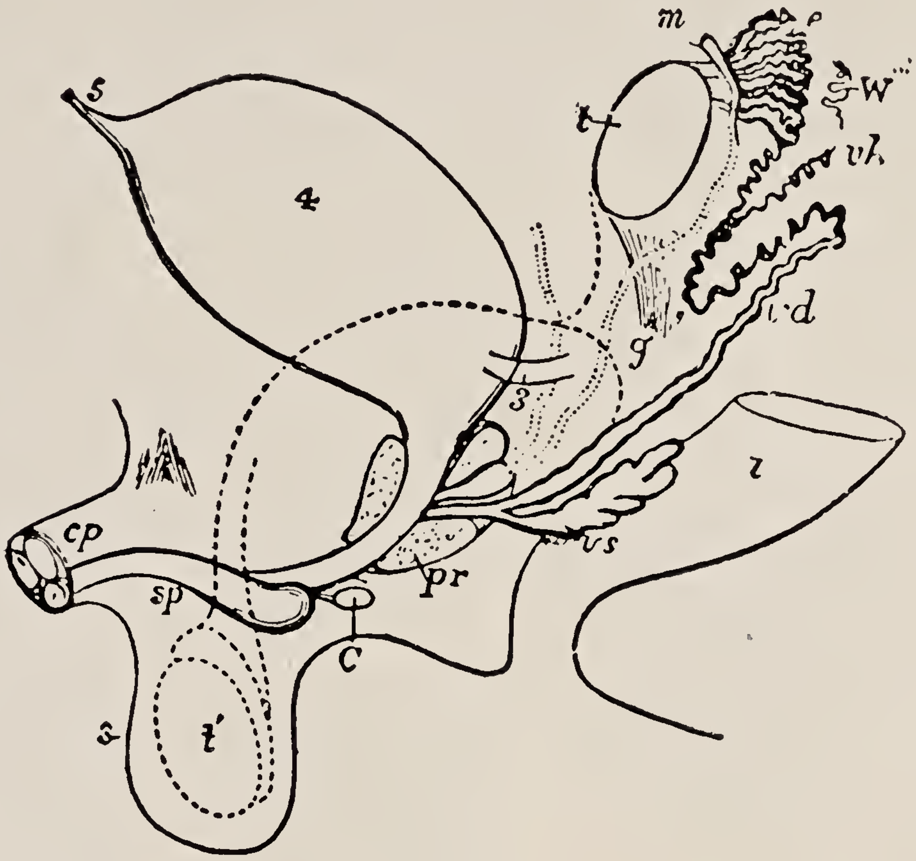

Fig. 2. Diagram of the male type of sexual organs (after Allen Thomson). The testicle, at t, is in its original position and t′, as shown in dotted lines, is its descent into the scrotum showing how the vas deferens, by this descent, is looped over the ureter (3). (From Prentiss.)

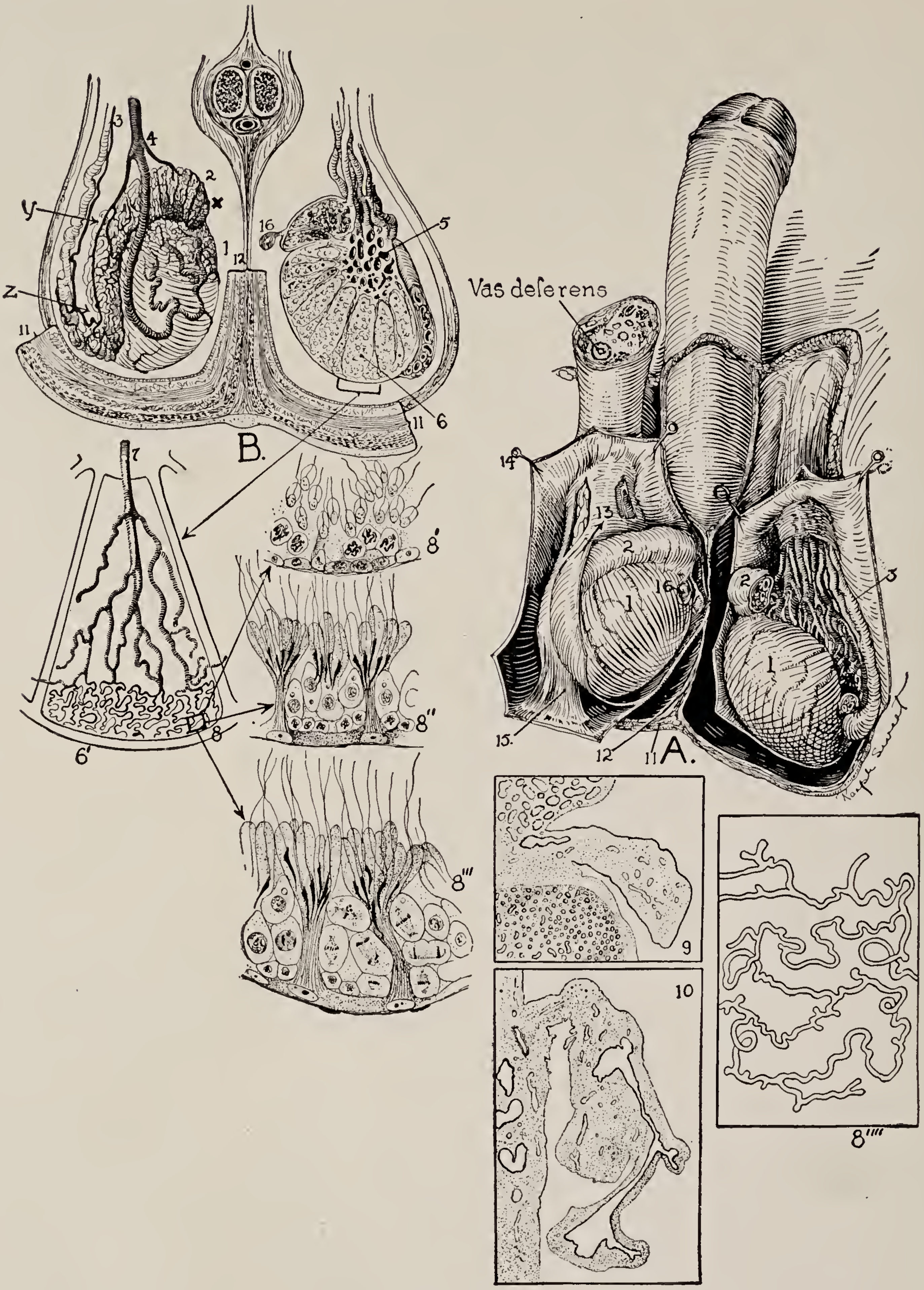

FIG. 3. The Testis and Testicular Tunics. A, The relations of the testes in the scrotal sac are represented in detail in B. 1, Testis. 2, Epididymis. 3, Vas deferens. 4, Spermatic artery. 5, The corpus of Highmore with rete vasculosum. 6, One of the lobules represented schematically in 6' with its innumerable seminiferous tubules, 8, showing the process of spermatogenesis in 8', 8'', 8'''. 8'''' represents a more detailed diagram of a seminiferous tubule with marked convolution, blind divisions, and anastomosis. 9 and 10 represent cross-sections of the vestigial appendages, 16. 11, The dartos which unites in midline to form the septum, 12, that sends a fascial covering up to the bulb. 13, Tunica vaginalis. 14, Dartos held back. 15, Scrotal ligament. 16, Hydatid. The epididymis is shown in B; x, globus major, y, body, and z, globus minor. (Largely after Testut.) VOL. 3. 1036.

The seemingly complicated structural arrangement of the testicular tunics is greatly simplified by recalling the fact that the testicle is ontogenetically as well as phylogenetically an abdominal organ which descends through the inguinal canal into the scrotum normally shortly before birth. Its tunics are merely structures of the abdominal wall which have been appropriated by the testicle in this descent. The tunica vaginalis invests the testicle and epididymis completely except at the points of contact between the two and posteriorly where the blood-vessels and nerves enter the organs from the spermatic cord. A dense fibrous adhesion exists between the most dependent part of the scrotum and the tunica vaginalis. This is called the scrotal ligament and is supposedly a remnant of the embryonic gubernaculum testis. This structure must be severed in operative procedures before the testicle and tunica vaginalis can be delivered from the scrotum. The visceral layer of the tunica dips in and lines a narrow interval

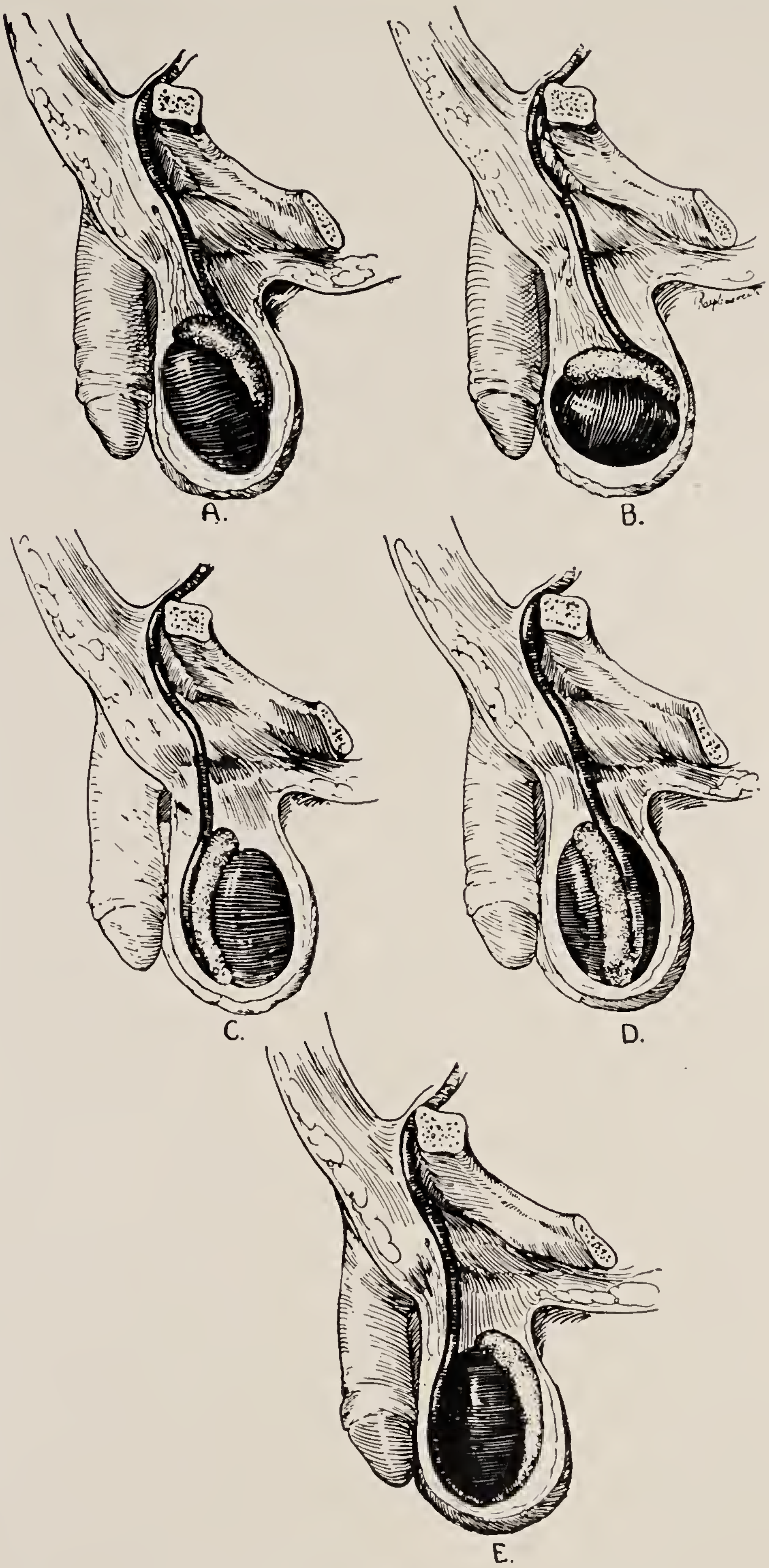

Fig. 4. Diagram of the relationship and position of the epididymis and testicle. A, normal relation. B, superior inversion. C, anterior inversion. D, lateral inversion. E, loop inversion. (After Campbell.)

between the lateral aspect of the testicle and the body of the epididymis. This is called the sinus of the epididymis, or digital fossa. In operative procedures on the testicle, vestigial, embryonic, ovoid structures, about 0.5 cm. in their greatest diameter, are usually encountered. They are the appendix testis, or hydatid of Morgagni, arising in the groove between the globus major and the testicle, and the appendix epididymis, also called hydatid of Morgagni, which is attached to the globus major. Both the appendix testis and the appendix epididymis consist histologically of vascular connective tissue in which are irregular canals lined by columnar epithelium, sometimes ciliated. They represent the remnants of the müllerian ducts. The organ of Giraldès, or paradidymis, is a small body, only occasionally seen in the adult, situated in the anterior part of the cord just above the globus major.

Finer structure of the testis. The testicle is completely invested by a dense, unyielding, fibrous membrane, the tunica albuginea, which sends radiating septa into the substance of the gland (Fig. 5) and forms the fibrous framework of the parenchyma. Between these septa is the glandular tissue which contains the greatly convoluted seminiferous tubules. These tubules are surrounded by a very delicate supporting matrix composed of connective tissue containing the interstitial cells of Leydig which furnish the internal secretion of the testis. The seminiferous tubules (tubuli contorti) are lined by the basal cells of Sertoli and the cells of the spermatogenic cycle. In inflammatory processes there is an increase in the interstitial tissue which crowds out the tubules with amazing rapidity and results in testicular atrophy. In testicular wounds the loosely coiled tubules often string out at great length, resembling a switch of blonde hair. The tubules have relatively wide lumina with a diameter of from 200 to 300 microns. There are, however, wide variations not explainable by age. There is very little intertubular connective tissue. Sappey, in 1889, made a thorough histologic study of the testis and found it to contain from 200 to 250 lobules, each of which enclosed from 70 to 80 cm. of canals. He estimated the total length to be about 280 or 300 meters. In a similar study, in 1925, Bassom and Osterred judged the total length to be about 250 meters, while some authors have estimated it to be as high as 800 meters (Schafer). Mollendorff considered only the more conservative estimates. The tubules converge at the hilum of the testis into the tubuli recti and thence into an anastomosing network, called the rete testis. This region is also designated as the mediastinum testis, or corpus Highmori, and is situated at the posterocephalad aspect of the testis. Here the tubules converge, forming from

12 to 15 channels known as the ductuli efferentes leading into the globus major of the epididymis. A schematic diagram of the tubular system is given in Figure 5. The walls of these tubules consist of fibro-elastic tissue. They are lined by a several-layered epithelium, the cells representing the stages of spermatogenesis. From the wall to the lumen of the tubules in the adult testis (see Fig. 3, 8, 8′, 8″, 8‴) can be seen, at successive levels, spermatogonia, primary spermatocytes, secondary spermatocytes, spermatids and spermatozoa attached to the sustentacular cells (cells of Sertoli). It is believed that the spermatids draw nourishment from the sustentacular cells during their process of metamorphosis into ripe spermia, and for this reason the Sertoli cells are also called trophocytes.

The consideration of the cells representing spermatogenesis is of particular importance from a pathological viewpoint since it is believed that the malignant tumors of the testicle may well arise from one or more of these sex cells. Since the cells of these tumors are now known to secrete a gonadotropic hormone, it also presents a physiological aspect of equal importance.

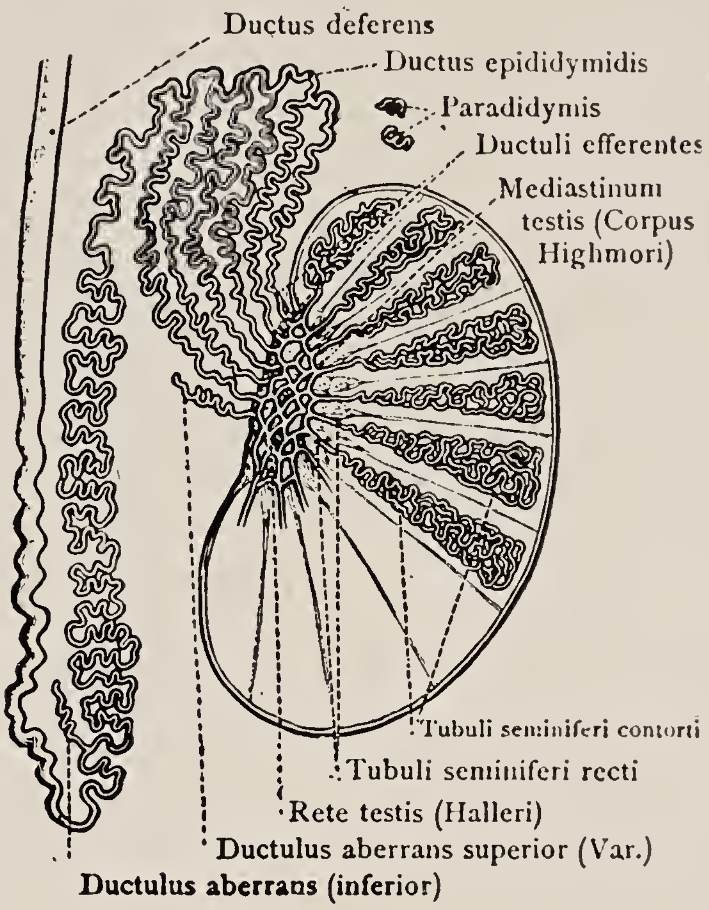
Ductus deferens
Ductus epididymidis
Paradidymis
Ductuli efferentes
Mediastinum testis (Corpus Highmori)
Tubuli seminiferi contorti
Tubuli seminiferi recti
Rete testis (Halleri)
Ductulus aberrans superior (Var.)
Ductulus aberrans (inferior)

Fig. 5. Diagrammatic representation of the testicular framework and showing diagrammatically the arrangement of tubules in this. (From Toldt.)

The infantile testis contains none of the cells mentioned above as seen in spermatogenesis. According to Mollendorff, there is little change in the primitive sex cells (the mother cells of the spermatogonia and sustentacular cells) from early embryonic life (14 cm.) until the beginning of puberty (age 12). In the undescended testes of cryptorchids the degenerate seminal tubules are lined with only one type of epithelium, the constituent cells representing the common ancestors of the trophocytes and sperm cells. Normally at puberty, if the testes are descended into the scrotum, the spermatogenic process may be visualized easily in microscopic sections. When finally the latent mother cell differentiates into spermatogonia these become extremely active, as evidenced by the numerous mitotic figures. Certain of these cells become spermatocytes which apparently lose the power of rapid division but gain in growth and energy. During growth there are nucular changes, after which the cell becomes finally mature. At this stage it rapidly divides twice. These are called the maturity divisions. In this the chromosomes are reduced to one half their original number. From these the spermatids and adult spermatozoa arise. (Fig. 6.)

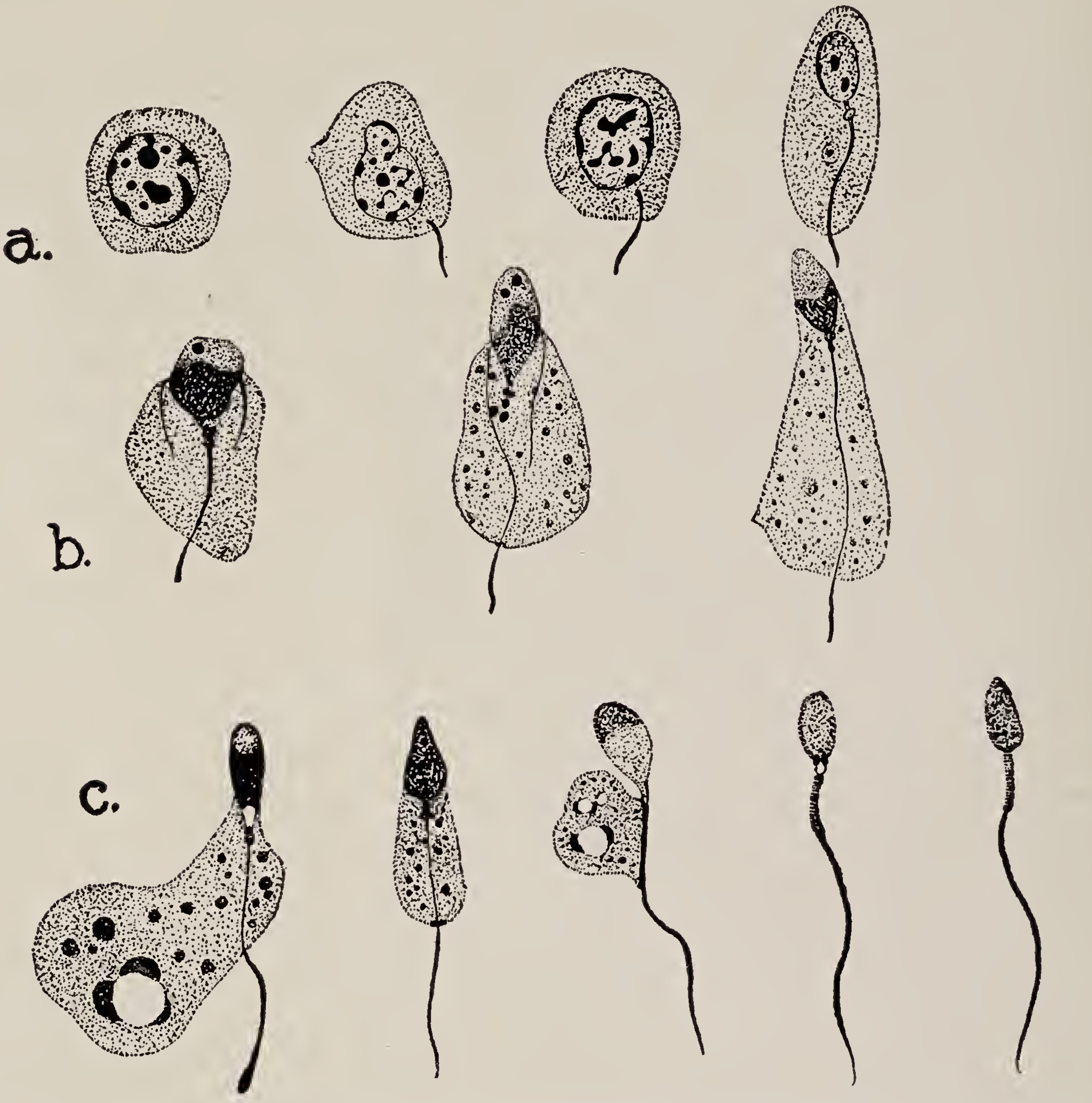

Fig. 6. A detailed representation of the development of a spermatozoön (after Branca). a, Stage of idiosome (idiozone). b, Stage of caudal cowl (*manchette caudale*). c, Stage of spermatozoid (*spermatozoide*).

The spermatic ducts: The epididymis. The epididymis should not be considered a part of the testicle but, rather, the convoluted origin of the vas deferens. It consists of a single tubule, of thousands of convolutions which give the epididymis its bulk. It is estimated that if this tubule were uncoiled it would measure 20 feet in length. The epididymis occupies the posterior vertical aspect of the testicle "like the crest of a helmet" and is included with the testicle in the folds of the tunica vaginalis. (See Fig. 3.) It consists of three parts: the head, or globus major, which is the largest part (it is at this point that the ductuli efferentes connect with the tubules of the epididymis); the body, or mid-portion, and the tail, or globus minor, which continues as the vas deferens. The tube of the epididymis, some 6 to 8 meters long and 0.4 mm. in diameter, is composed, from without inward, of connective tissue adventitia, a circular layer of smooth muscle, and basement membrane lined by a double row of epithelium, an outer layer of tall columnar cells and an inner layer of short cuboidal or conical cells. Some of the cells are ciliated; others appear to have a secretory function.

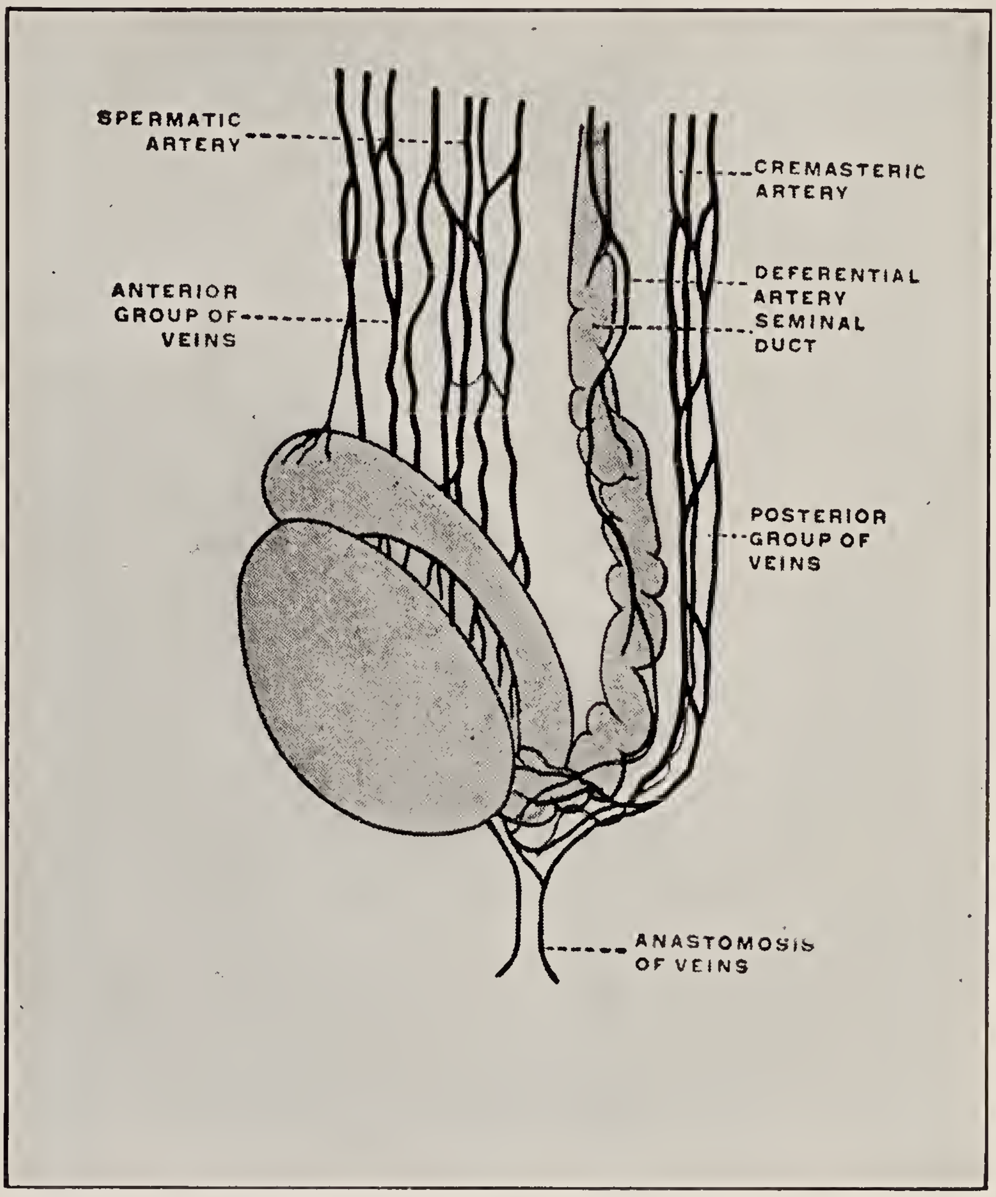

FIG. 7. Diagrammatic representation of the blood supply of the epididymis and testicle. It is seen how relatively small is the artery of the vas and, even though there is a free anastomosis at the globus minor with the other blood-vessels of the testicle and epididymis, this artery has been found insufficient to prevent testicular atrophy when the others have been sacrificed surgically. (From Cabot.)

The blood supply of the testicle. An exact knowledge of the blood supply of the testicle is essential in surgical procedures in this region. The chief artery of the testis is the internal spermatic which arises from the aorta just below the renal arteries, sends a branch to the ureter as it crosses, and passes, with the spermatic cord, through the inguinal canal to the testicle (Fig. 7) on the medial side of the body of the epididymis. Before entering the testicle it sends a small branch to the globus major. The second artery of importance is the deferential artery, a branch of the inferior vesical (sometimes the superior vesical) which lies in intimate contact with the vas until it reaches the epididymis, of which it supplies the body and tail. A third artery, the cremasteric or funicular, which is a branch of the deep epigastric, runs in the external sheath of the cord to the lower pole of the testicle and epididymis. Picque and Worms showed that, in every case, there is an anastomosis between the three arteries. Theoretically, sufficient blood supply to the testicle ought to be maintained if any two of these vessels are sacrificed. Practically, it is known that the internal spermatic artery may be severed without resultant atrophy of the testicle, but it does not seem likely that such would be the case if both the internal spermatic and the deferential artery were sacrificed. Mixer stated that severance of the spermatic artery in operations for cryptorchism will cause atrophy of the testicle in 85 per cent. of the cases. Within the mediastinum of the testicle the arteries break up into numerous branches which follow the septa and form a capillary plexus about the tubuli contorti. The veins run a parallel course.

The spermatic veins emerge from the testicle and accompany the arteries, forming the pampiniform plexus. The plexus forms a part of the cord on each side, terminating near the internal inguinal ring in a single trunk, the right entering the vena cava, the left, the left renal vein. These veins usually are provided with valves but the one at the orifice of the left is sometimes lacking. Varicocele, which consists of dilatation and tortuosity of the veins of the plexus, occurs usually on the left side, as the anatomy would lead one to surmise; the entry of the spermatic vein into the renal vein at a right angle and the frequent absence of the valve on this side lend themselves to such a formation. On palpation, the sensation is of " a bag of worms." The presence of varicocele is so universal that it may be called physiological except in rare cases in which it has reached such dimensions as to cause discomfort. It is well to remember that certain abdominal conditions, such as tumor of the kidney, sometimes cause the formation of large varicoceles by means of venous obstruction. In resecting the veins of a varicocele great care must be taken to avoid injury to the internal spermatic artery which courses in the midst of the plexus.

The lymphatics of the testicle. The rather prevalent belief that the lymphatics of the testicle drain into the inguinal glands should be dissipated. The testicle, epididymis, vas, and tunica vaginalis have no connection whatsoever with the inguinal lymph nodes. The primary lymph zones of the testicle were anatomically demonstrated by Most in 1899 to lie in the neighborhood of embryologic origin. (Fig. 8.) His findings later were confirmed clinically, as well as experimentally, by Cuneo, Jamieson and Dobson, and others. The testicle was originally an intra-abdominal organ situated just below the kidneys, and the pre-aortic lymph nodes are the primary nodes into which the testicular lymphatics drain, even though the testicle later changes its position by descending into the scrotum. A knowledge of the facts is essential to the correct diagnosis and treatment of diseases of the testicle.

Nerves. The nerves of the testicle accompany the spermatic artery and are derived from the aortic and renal plexuses.

The vas deferens and the spermatic cord. The vas deferens is the excretory duct of the testicle, being a continuation of the epididymis. It is coiled at its junction with the globus minor but quickly becomes a straight tube in its ascent as one of the elements of the spermatic cord. The latter consists, in addition to the vas, of the nerves, blood-vessels, and coverings of the testicle, and serves as a pedicle for the testicles. The vas deferens is a tough, resistant, bluish-white tube, from 2 to 3 mm. in thickness and almost cartilaginous in consistency. The vas is about 40 or 45 cm. in length and passes upward through the inguinal canal, turns down into the pelvis, curves around the side of the bladder, and loops over the ureter, dilating just before entering the prostate gland to form the ampulla of Vater. At the base of the prostate the vas is joined

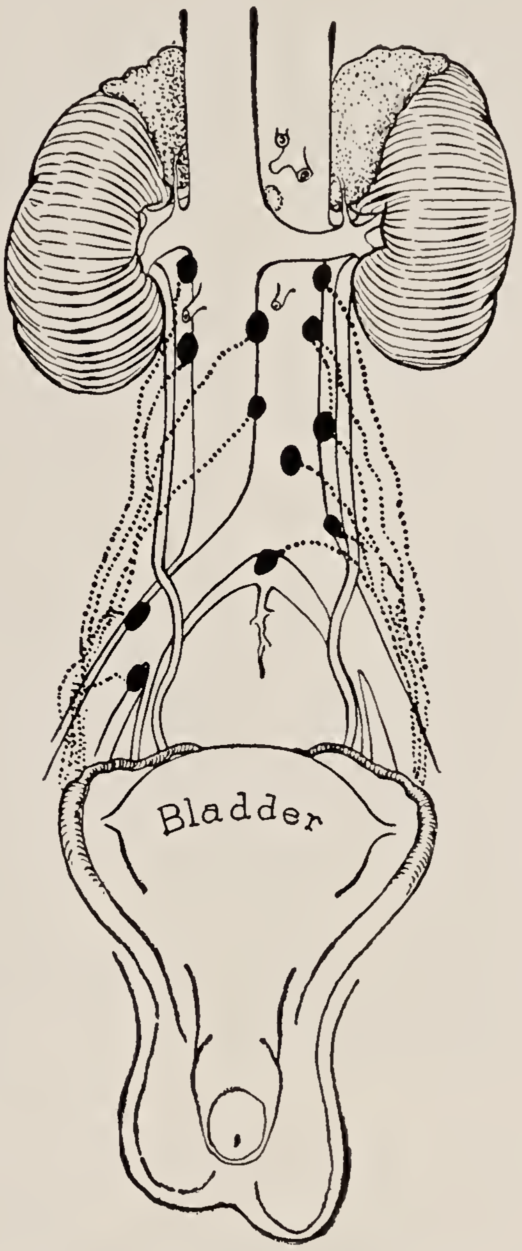

Fig. 8. Diagrammatic representation of the primary lymph zones of the testis, the retroperitoneal area over the aorta and vena cava between the renal pedicle and common iliac.

by the duct of the seminal vesicle to form the ejaculatory duct which traverses the prostate and opens on the verumontanum or colliculus seminalis. (Fig. 9.) The vas is lined by a two-layered columnar epithelium which rests on a basement membrane. This is covered by a stratum of connective tissue which, with the epithelium, lies in longitudinal folds. Outside this are three well-developed layers of smooth muscle — inner and outer longitudinal and middle circular, and finally a layer of connective tissue.

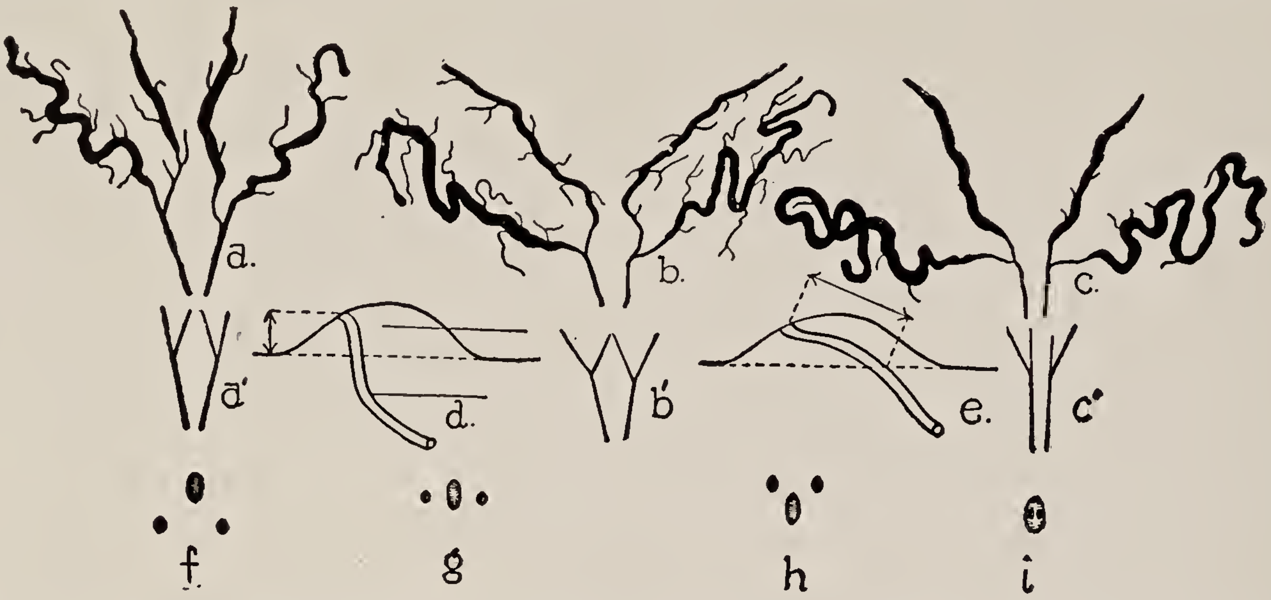

Fig. 9. The varying relation of ampullæ and seminal vesicles to form the ejaculatory ducts. In *a*, the vas (ampulla) opens into the ejaculatory duct. In *b*, both open at an equal angle to form the duct and, in *c*, the ejaculatory duct passes straight off into the vas, the seminal vesicle opening from the side, as represented diagrammatically in *a'*, *b'*, and *c'*. *d* shows the deep penetration of the ducts to open on the verumontanum and *e*, the superficial course of the opening. *f*, *g*, *h*, and *i* represent the variations in relationship of the duct orifices to the orifice of the sinus pocularis. (After Ivanizky.)

ANOMALIES

1. **Structural malformations** of the testis unassociated with malposition are rare.

a. **Anorchism,** or congenital absence of both testes, is unproved except in stillborn monstrosities. Eleven cases of anorchia diagnosed at autopsy have been recorded (Rea, '38) but the probability of degeneration or atrophy secondary to cryptorchism or other abnormality cannot be denied.

b. **Monorchism,** or development of only one testicle, has been reported but could be confused easily with maldescent and hypoplasia. The one testis usually undergoes a compensatory hypertrophy and the condition is without clinical significance, unless the single testis is injured or diseased. Rea ('38) collected 29 instances of monorchism and added 6 personal cases in which the diagnosis of unilateral cryptorchism had been made but thorough surgical exploration failed to reveal the missing organ.

c. **Synorchism,** or intra-abdominal fusion of the testes, has been discovered at operation or autopsy.

d. **Polyorchism.** Judged by the test of microscopic confirmation of the supposed supernumerary testis, there are perhaps not more than 15 authentic cases. The majority of these, i. e. cases recorded as polyorchism, are simply duplications (testis bipartitus) or subdivision on one side without duplication of the vas. The epididymis elongates to serve both masses. Hernia is usually associated and, with two testicles normally descended, operation is undertaken to cure the hernia or remove a supposed cyst of the cord, or there may be an associated hydrocele. Intra-abdominal duplication has little significance unless complicated by malignancy or inflammation, but its possibility should be kept in mind. There may be duplication of the whole tract, testis, epididymis and vas (as in the cases of Turner, and Marsh) or the supernumerary portion may have no epididymis or vas (case of Schleimer). Variations of maldevelopment are understood by recalling methods of urogenital union in which the cranial tubules of the epigenitalis fail to degenerate and thus form various types of union to the supernumerary mass. Duplication of the primary excretory duct at an early period of growth would be cause for duplication of the whole tract. The condition is to be differentiated from ectopia transversa. The various types and combinations of polyorchism which have been reported are indicated in Figure 10.

2. **Anomalies of position** are of great clinical importance. They are of two kinds: (a) retention at some point of normal descent and (b) abnormal placement in the course of descent.

There are many hypotheses as to the cause of ectopy, but there is no uniformity of opinion regarding all the details of the innumerable possible developmental defects which might result in retention or ectopy. They may concern the internal relation of testicle and epididymis, the inguinal fold and gubernaculum, the cremasteric muscle and inguinal canal, or the structural route along which the testis must pass after leaving the canal. The possible influence of some hormonal dysfunction, suggested by the medical treatment of the condition, should not be discounted.

a. **Retention, or cryptorchism,** is of three types: (1) abdominal, (2) inguinal and (3) puboscrotal. When intermittent retention or

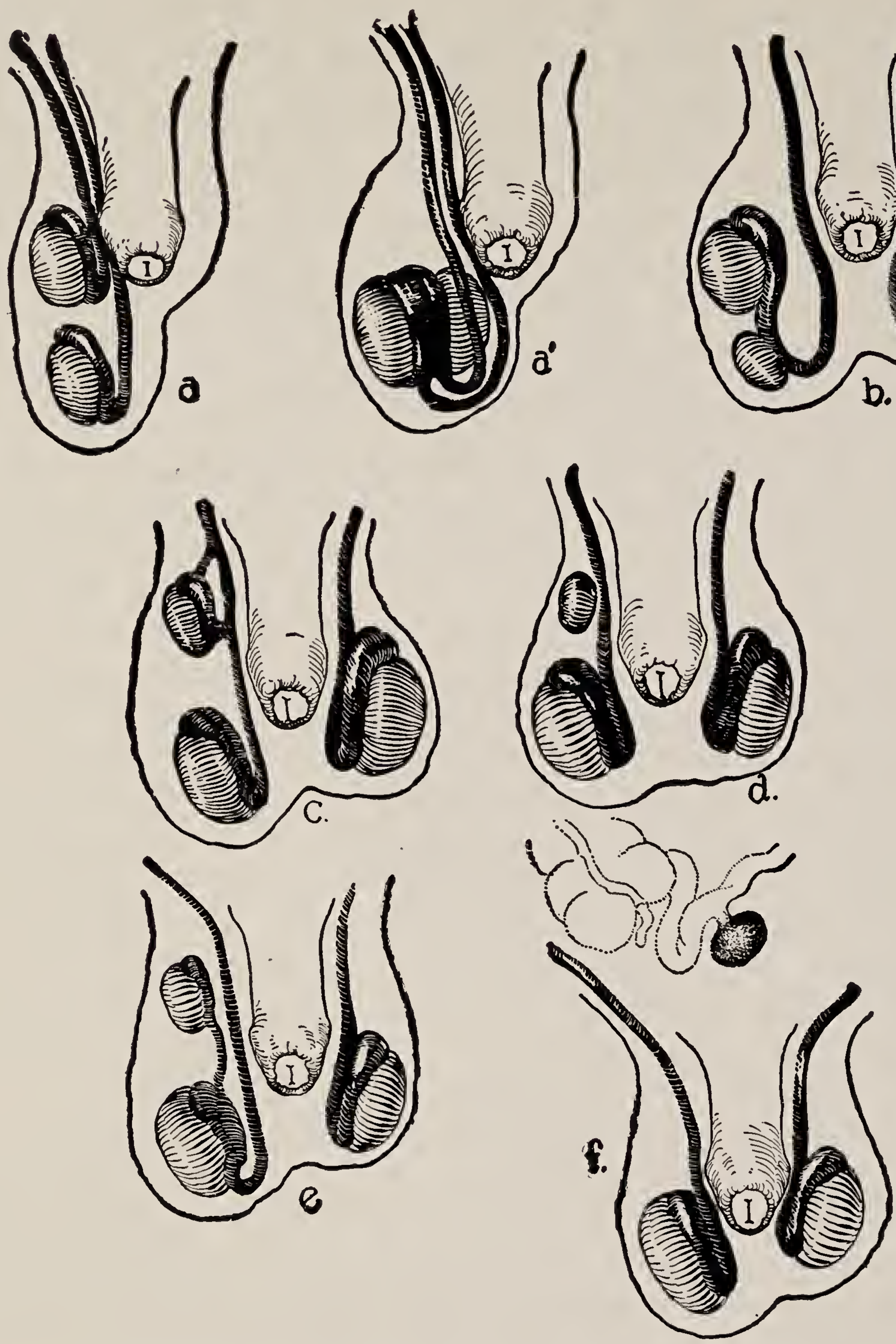

Fig. 10. Diagrammatic representation of the different types of duplication on one side. (After Oberndorfer.) *a*, Transversa; normal complete tract in same scrotal sac, opposite side empty. *a'*, Transversa; two testicles with common epididymis but two vasa and vesicles. *b*, Supernumerary testicle with elongated epididymis. *c*, Supernumerary testicle with two epididymes and split vas. *d*, Supernumerary testicle without epididymis or vas. *e*, Supernumerary testicle with its own epididymis and vas opening into the other epididymis. *f*, Pedunculated supernumerary testicle attached to ileum but without epididymis or vas.

spastic retraction of the testis is ruled out, a differentiation which decreases the number of apparent puboscrotal maldescents, inguinal retention is found to be the most common. Some writers do not recognize puboscrotal maldescent, but such a testicle, which cannot be brought into the scrotum by manipulation, is subject to injury and atrophy equally with the inguinal type.

1. *Incidence.* Incomplete descent or nondescent of the testis is more common in infancy; in one series of patients, from one to four months of age, it was present in 14 per cent. It is ten times more common in boys than in men.

Incidence of Cryptorchism

In Children

1 to 11 with hernia (Southam and Cooper).

1 to 14 with hernia (Mixter).

1 to 30 under 14 (Coley).

1 to 50 between 14 and 21 (Coley).

1 to 4 in new-born (Wrisberg).

1 to 25 in 450 males born at term (Hofstaetter).

1 to 3 in 150 prematurely born (but in from 8 to 10 days almost all of these testicles were in the scrotum or had slipped out of the inguinal ring) (Hofstaetter).

In Adults

1 to 500 in 6,962,543 Austrian recruits (Ziebert).

1 to 300 in American army.

1 to 150 in American recruits of World War.

1 to 200 in 10,000 Scottish recruits.

1 to 150 in 57,000 surgical admissions (Manchester Infirmary).

1 to 200 in 12,500 admissions, Brady Urological Institute (Young).

1 to 50 in 48,000 hernia cases (Eccles).

Undescended testis is present in about one in every 25 to 30 boys under fourteen years of age and in approximately one in every 250 men over twenty-one years of age. The condition is usually unilateral and is found more often on the right than the left.

2. *Diagnosis.* Absence of the testis from the scrotal sac is not in itself pathognomonic of true cryptorchism. Intermittent or physiological retention is of common occurrence in children and must be differentiated from true retention since no therapy, hormonal or surgical, is indicated in the former condition. In the retractile type there is often a history that the testis has been seen lying in the scrotum. The scrotum is well developed and the condition is usually bilateral. Hernia as a rule is not present.

In the retained type, the scrotum on the affected side is undeveloped, the condition is usually unilateral and concomitant hernia is common.

Careful examination is necessary in order to differentiate between false and true retention. Hamilton and Hubert ('37) recommend a routine method which seems worthy of use. Of primary importance is adequate relaxation of the muscles that can cause retraction (cremaster). The patient should lie with the legs apart. Heat is then applied to the groin, scrotum and perineum. Gentle examination should be carried out lest the child become frightened and, by reflex action, contract the cremaster muscle. Frequent examinations may be necessary in order to overcome this. If the testicle does not descend, pressure should be applied to the abdomen, which maneuver may force the testis into the scrotum. If manipulation with the fingers does not produce results, the diagnosis of true cryptorchism may be made.

Browne ('38) took issue with most writers when he said that a testis felt in the region of the inguinal canal cannot be in the canal because a small testicle cannot be felt through the external oblique aponeurosis. It is his opinion that such a testicle lies between Scarpa's fascia and the external oblique muscle lateral to the inguinal canal, which position is but a variation of normal placement. He claims that the remarkable success which hormonal therapy has enjoyed has resulted from its action on this type of retention.

3. *Complications of cryptorchism,* for the prevention of which hormonal therapy, operation, or a combination of both is advised, are: (1) the concomitant existence of inguinal hernia or potential hernia, (2) the occurrence of atrophy and, when the condition is bilateral, sterility and imperfect culmination of the secondary characteristics of sex, (3) the greater tendency towards torsion, 50 per cent of which occurs in undescended testicles, (4) the greater likelihood of injury if the testicle is partially descended, and (5) the susceptibility of the undescended testis to malignant degeneration.

Hernia is a very common complication. It is usually of the indirect inguinal variety, but occasionally is interstitial, either under the skin, between layers of abdominal muscle, or under the peritoneum.

Testicular atrophy and sterility are the rule with abdominally retained testes. Instances of parenthood or spermatogenesis are exceptional. The forms of eunuchoidism, hypogenitalism and infantilism seen in association with cryptorchism are related to endocrine disturbances other than those of the testis alone, particularly to disorders of the pituitary body.

Torsion of the testicle occurs relatively more frequently in those abdominally retained and most authors find that from 12 to 15 per cent of tumors of the testis have occurred in cryptorchids. Pace and Cabot ('36) made a histological study of 24 undescended testes, not only verifying the progressive atrophy which takes place, but finding unsuspected carcinoma in three of them.

The undescended testicle is heir to the same maladies as the normally descended organ. Failure to note the presence or absence of two testicles in the scrotum has led to mistaken diagnosis of appendicitis or strangulated hernia when the true condition was torsion or epididymitis of a retained gonad.

4. *Treatment of Cryptorchism.* Normally both testicles are completely descended at birth but it is not unusual for descent to be delayed. The optimum time to institute therapy is in dispute. Deming ('38) among others feels that atrophy may occur at the age of three or four years and consequently treatment should be started at or before that time. The majority of recent writers, however, believe that nothing is to be gained by such early treatment, and, on the other hand, harm may be done. It has been noted that in probably half the patients under 6 years of age who receive adequate hormonal therapy more or less enlargement of the external genitalia takes place and, though in most of these regression occurs, in a few cases it has not (Bigler et al ['38], Nixon ['38], Thompson et al ['38], etc.). It seems best therefore to start treatment between the ages of 7 and 12, before puberty sets in.

Enough time has now elapsed, since Schapiro ('30) first reported favorable results with hormonal therapy for cryptorchism, to permit certain conclusions concerning such treatment. Either anterior pituitary-like hormone from the urine of pregnant women (antuitrin S, APL, follutein, Korotron) or anterior pituitary hormone (antuitrin G, maturity factor, prephysin) may be used. The former seems to be the more popular. The dosage as well as the interval between doses is empirical. The hormone may be given every day or only twice a week. While some authors give only 200 rat units a week (McCahey, '38), the majority prefer between 500 and 750 units a week (Turner, ['38], Spence and Scowen ['38], Rea ['38]). While the total dosage varies considerably, the average course advocated is between 3000 and 4800 rat units administered over a period of from 4 to 10 weeks. A few report higher unitage than the foregoing with no untoward results, but it is questionable whether this is necessary. If such a course of treatment meets with no response or only partial response, a second similar regime is carried out three or four months later. If the testis does not reach the bottom of the scrotum as a result of this hormonal therapy, surgical intervention is indicated. Most authors agree that bilateral cryptorchism responds more readily than the unilateral type.

Nixon ('38), in an excellent review on this subject, tabulated the results of therapy with pituitary or pituitary-like substances in 388 patients with 574 undescended testes, reported by 24 authors. The measure of success enjoyed by such treatment varied between 19 and 100 per cent! It has now become apparent that in cases of true cryptorchism hormonal therapy will cause descent of the testicle in from 20 to 35 per cent of cases.

Browne ('38), however, feels that all testes that respond to hormonal therapy would later have descended spontaneously and that those that fail to respond do so because of anatomical reasons which can only be corrected by surgery. Even if this is true, it seems that the wisest plan is to administer gonadotropic hormone to all preadolescent cryptorchids if only to discover, before puberty, the patients who will require surgery, because, if spermatogenic function is to be preserved, early intervention is imperative. Furthermore, though it fail to cause descent, hormonal therapy prepares the field for operation. The testicle enlarges, the blood supply to the organ increases, the vas deferens becomes longer and larger and the scrotum undergoes development.

It is of prime importance that these patients be carefully followed because of occasional untoward effects of the hormone on the external genitalia. Powell ('39) reported the occurrence of acute retention due to prostatic hypertrophy which developed in a boy of 17 following prolonged administration of gonadotropic hormone, while several instances of enlargement of the prostate, judged by rectal examination, have been cited (Thompson and Heckel, '38).

If gonadotropic hormonal therapy proves inadequate, or if a congenital hernia exists, surgery is indicated. A successful orchiopexy must accomplish (1) preservation of the blood supply and nerves to the gonad, (2) cure of the concomitant hernia, (3) formation of a loose scrotal sac when small or rudimentary, and (4) placement of the testicle in the bottom of this sac without undue traction upon the spermatic cord. This latter tenet can only be fulfilled by careful division of adhesions and minor short vessels so that adequate length of the cord is obtained. Occasionally, needed length can only be had by dividing the inferior epigastric vessels, opening the transversalis fascia throughout the length of the wound and allowing the cord to course beneath it, so that it emerges at the external ring (Deming, '37). Whether the testicle is held in the scrotum by a pursestring suture at the neck of the scrotum (Bevan '29), or by anchoring it to the thigh (Torek), is not so important as the thoroughness with which the cord is freed. The Torek operation or one of its modifications appears to give the best results. If the cord is under tension at the completion of the operation, the further administration of pituitary hormone may be of advantage (Deming, '38).

The abdominally retained testis is the most difficult to treat. Hugh Cabot ('38) described a three-stage procedure for this condition. At the first stage the testicle and cord are freed of all adhesions and enough peritoneum is left on the gonad to make a tunica vaginalis. The testis is then tacked to the tissues of the inguinal canal in the region of the external ring. At least one year should elapse before the second step is undertaken. At this time the cord is again freed. A hydrocele has developed which makes freeing of the testicle easier. The gonad is then placed in the scrotum and attached to the thigh. At the third stage the testicle is freed from the fascia of the thigh.

The treatment of retained testes after adolescence presents another problem. Most authors agree that the incidence of malignant degeneration in the undescended organ is higher than in the normally descended one. Chevassu ('39) reported 5 cases in which malignancy developed some years after orchiopexy. One therefore questions whether an atrophied testicle should be preserved. Marion ('39) stated that, if hernioplasty is indicated in a post-adolescent patient with concomitant cryptorchism, orchidectomy should be performed. If the condition is bilateral, however, he carries out bilateral orchiopexy for psychic reasons.

b. **Displacement** (**ectopy**) of the testis from its normal course of descent is closely related to retention. Six positions are possible:

1. *Perineal ectopy.* The testis lies in the perineum, usually about an inch above the anus and just lateral to the median raphe. This is the most common type of ectopy, more than 100 cases having been reported (Jones and Lieberthal, '38). Coley reported a case

of perineal ectopy accompanied by a congenital perineal hernia, as would be expected since the processus vaginalis always accompanies the testis.

2. *Crural or femoral ectopy.* The testis lies in Scarpa's triangle.

3. *Penile ectopy.* The testis lies in the soft tissues between the pubis and the root of the penis.

4. *Interstitial inguinal ectopy.* The testis lies properitoneally or in front of the aponeurosis of the external oblique muscle.

5. *Transverse ectopy (or paradoxical descent).* Both testes descend by the same inguinal canal. Both may be normal or one testicle may have an atrophic vas and epididymis leading to it, as in the case of Howald ('28); usually transverse ectopy is associated with some müllerian anomaly (pseudohermaphrodism). In the sac of an inguinal hernia of an adult, MacKenzie ('34) found two testicles with separate epididymes and vasa, between which was attached a long mass which proved histologically to be a hypoplastic uterus with tube and vagina.

6. *Pelvic ectopy.* The testis drops down into the true pelvis (Foth).

The complications to which congenital ectopy is liable include trauma, depending upon the position of the testicle, atrophy and hernia. Besides these should be mentioned the afflictions met with in the normal organ, including inflammation. Cancer has not been reported in such testes (Rea, '38).

Treatment. The treatment is surgical. Inversion and retroversion are discussed under local manifestations. Acquired ectopy, as a result of trauma or induced to escape military service, is called luxation of the testicle.

PHYSIOLOGY

The fundamental function of the testis is reproduction through the production of spermatozoa from the germinal cells of the seminiferous tubules. It is also an important organ of internal secretion, the growing knowledge of which has placed the gonads in a prominent position in endocrinology.

External secretion. The external secretion of the testis consists of the spermatozoa derived from the seminal epithelium lining the seminiferous tubules of the testis. Spallanzani (1784) was the first to show that the presence of spermatozoa in the semen was an essential factor in fertilization, and to Kölliker (1841) we are indebted for the discovery that the sperm arise from the cells of the testis. In addition, the seminiferous tubules secrete a fluid which serves as a mechanical medium in which the spermatozoa move, and which is probably nutritive as well.

There appears to be no seasonal cycle of spermatogenic activity in man. Although few clinical observations have been made, it is quite clear from animal experiments that other endocrine organs, particularly the pituitary body, influence spermatogenesis. When adult male rats undergo hypophysectomy, complete maturation of germ cells ceases. Following removal of the pituitary gland from immature rats the testes fail to mature unless fresh pituitary substance is implanted (Smith, '30). The administration of pituitary substances to normal immature animals, moreover, hastens the onset of spermatogenesis.

In man, the important physical factor influencing the testis is temperature. This has been carefully worked out by Moore ('39) who showed that when heat is applied to the gonads degeneration of seminiferous tubules takes place. The same result occurs in experimental cryptorchism. Sterility is the rule when the testes remain undescended.

Vasectomy has been shown to have no untoward effect on spermatogenesis, thus refuting the claims of Steinach ('20).

Internal secretion. From time immemorial it has been recognized that the testis exerts an influence on the organism independent of its purely reproductive function. Although the idea of the internal secretions is a development of late years, the indisputable evidence of its action on the organism was long ago apparent to anyone who observed castrates, either human or animal, in their failure to develop secondary male characteristics, their loss of sexual ability, and their development of a physical resemblance to the female.

In 1849, Berthold transplanted the testes of cocks into their abdominal cavities and observed that the masculine sexual qualities were apparently preserved through an effect on the blood. Foges ('03) stated that the testes controlled the development of the male characteristics. Pézard ('11) observed that testicular grafts had a masculinizing effect which he attributed to the presence of a specific male hormone. Developments in this field during the past ten years have been nothing short of amazing. Both Loewe and Voss, and Funk and Harrow in 1929 recovered androgenic substances from male urine, while Butenandt ('31, '32, '34) reported the crystallization of androsterone and dehydroandrosterone from the same medium. The former substance was synthesized by Ruzicka in 1934. David ('35) recovered testosterone from fresh testes and both Butenandt and Ruzicka in the same year reported its synthesis as well as many related androgenic compounds.

Koch ('37, '39) described 27 androgenic substances which have been synthesized and studied. By far the most potent is testosterone and its effects are prolonged by using the proprionate ester (Parkes, '36) which need only be administered twice a week.

The involution of the secondary sex organs following castration results from the absence of the internal secretion of the testis but the administration of androgenic hormone completely counteracts these changes.

The retrogression produced in the secondary reproductive organs in the absence of testicular secretion forms the basis for the many tests utilized to indicate the presence of androgens. The reader is referred to the literature for details of such tests (Koch, '39).

Only small amounts of testicular hormone are found in the urine until puberty, then during the third and fourth decades it reaches its peak, after which time it is recovered in decreasing amounts.

The hormones of the testis and pituitary gland are closely interrelated. Thus, although the androgenic hormone controls the development of accessory sex organs, administration of gonadotropic (pituitary) hormone will also cause increase in the size of these glands, but only if the animal is not castrate. Conversely, in the hypophysectomized animal the testicular secretions cease to be produced and the changes typical of castration appear. This reaction may be reversed by the administration of pituitary hormone.

Clinically, the same effects obtain. Hamilton ('37), Kenyon ('38), and Vest and Howard ('38) reported growth of the penis and scrotum, enlargement of the prostate, changes in the distribution of hair, modification in the voice and increased frequency of erections following the injections of androgens. Many reports of sexual precocity which developed after the administration of gonadotropic hormone in the treatment of cryptorchism are also found in the literature.

INJURIES TO THE TESTICLE

The testicles, by reason of their tunics and their mobility, are rarely traumatized. Occasionally a direct blow, or sudden pressure, produces injury and their peculiar sensitivity renders relatively slight trauma exceedingly painful. Such injuries cause a sudden weakness, intense nausea and even vomiting, and there may occur profound systemic shock (or even instant death) out of all proportion to the extent of the injury.

CONTUSIONS

Pathological changes. Three degrees of testicular contusion are distinguished: (1) minute disseminated capillary hemorrhage into the connective tissue between the seminiferous tubules and the convolutions of the epididymis, often with tubular exfoliation; (2) effusions of blood from the size of a pea to that of a cherry, with rupture of the tubules; and (3) rupture of the tunica albuginea, with bleeding into the tunica vaginalis (Monod and Terrillon, and Terrillon and Suchard). Swelling, edema, and discoloration occur because of rupture of the vessels in the scrotal wall and hemorrhage into the tunica vaginalis. Suppuration rarely occurs, and the swelling usually subsides within a week or ten days. Should infarction occur, however, atrophy may follow. The formation of scar in any degree also may result in atrophy. Numerous cases of spontaneous atrophy of healthy testicles have been reported (Küttner, '24; Esau, '25). Andrews and Oslund ('27) noted the frequency of autolysis of the testicle in experimental work on the testes of young rats and guinea-pigs. They quoted ancient and medieval writers (Celsus, Fabricius, Paracelsus, Aquieta and Abbas) who described a method of producing eunuchs by squeezing between the fingers the testicles of infant boys. The testicles were softened previously by hot water.

Diagnosis. The history is usually all that is necessary in diagnosis. The possibilities of strangulated hernia, neoplasm, torsion or infection, however, must be kept in mind. Following the subsidence of the initial nauseating pain, there occurs a severe unremitting ache, aggravated by standing or walking. Trauma is an exciting cause of inflammatory conditions and is of importance in relation to the problem of workman's or industrial compensation, which is considered under a separate heading (Industrial Lesions of the Testicle).

Treatment. The treatment of contusion of the testicle requires absolute rest in bed, with the scrotum elevated, and the application of cold or hot compresses; if bleeding is present, cold applications are best, but if hemorrhage has ceased, hot applications to promote absorption are indicated. Hemorrhage may be excessive if the tunica is ruptured, and often requires surgery. The patient should be given the usual treatment for any signs of shock. The testicle should be watched carefully for the occurrence of infection. This usually does not ensue, but when it does, drainage should be instituted as soon as fluctuation is present. The prognosis should be guarded, because atrophy may follow even the slightest bruise, regardless of treatment. If contusion of the third degree occurs, atrophy is almost sure to result. Furthermore, the injury may be followed by a condition of chronic irritation characterized by tenderness and troublesome neuralgic pains. These generally disappear in time.

WOUNDS

Incised wounds heal promptly if kept clean, but require surgical attention if the tunica albuginea is opened to any extent. Careful and immediate repair of the incision in the tunica albuginea is essential to prevent hernia of the testis, a condition in which the yellow glandular substance strings out until the tunica albuginea is an empty shell, unless the loss is checked by closure of the wound. Every effort should be made to avoid infection and preserve as much of the testicle as possible.

INDUSTRIAL LESIONS OF THE TESTICLE (EPIDIDYMO-ORCHITIS FROM STRAIN)

Insurance companies, commissions of industrial medicine and some physicians regard acute affections of the testicle and epididymis arising on the basis of industrial injury or strain as primarily venereal and therefore nonindustrial. This is sometimes unfair to the workman. The prevalence of chronic gonorrhea and the frequency of acute exacerbations of the epididymo-orchitis following injury or strain do much to discredit such claims. It is the duty of the physician to differentiate the venereal exacerbations, for which workmen are not entitled to compensation, from the primary traumatic lesions of a purely industrial nature, for which they are entitled to it. This may be very difficult. In cases of pure trauma, without superimposed infection, the physician should be most particular in diagnosis and should define the condition as a contusion, hematoma, wound, torsion or luxation. Nongonorrheal infections are prevalent. Pyogenic prostatovesiculitis is about as frequent as the postgonorrheal type, and trauma or strain is just as often the exciting cause of an acute epididymo-orchitis. The reactions of trauma upon testicle and epididymis without either type of infection may differ little from those of a primarily infectious nature, but the *orchite par effort* of French writers is regarded by Barthélemy and Miramond as a misnomer. Strain may produce an aseptic traumatic lesion, but an epididymo-orchitis from strain is the result of infection and is secondary. The conditions to be differentiated, therefore, are:

- I. Trauma without superimposed infection (contusions, wounds, hematoma, infarction, rupture of veins of the pampiniform plexus, spasm of the cremasteric muscle, torsion and luxation).
- II. Trauma with secondary orchitis, epididymo-orchitis or epididymitis.
  - 1. Secondary to venereal disease (gonorrhea or syphilis).
  - 2. Secondary to tuberculosis.
  - 3. Secondary to a nonspecific focus of infection, either metastatic or ascending the vas.
    - *a.* General (teeth, tonsils, sinus, et cetera); metastatic.
    - *b.* Urinary (pyuria, renal — pyelonephritis; vesical — cystitis); metastatic or ascending.
    - *c.* Genital (nonspecific prostatitis with or without a history of gonorrhea); usually ascending.
- III. Primary inflammation of testicle or epididymis without trauma; metastatic or ascending.
    - *a.* Specific.
    - *b.* Nonspecific.

The differentiation of the foregoing conditions will require a most careful and complete history and examination. The malingerer or untruthful patient is difficult to detect. The findings on examination of the lower tract must be collected step by step and may be complete only after weeks of observation and study. The acute condition often requires treatment before the final steps of examination can be undertaken. The difficulties of diagnosis, and the essential elements of time and treatment in making it, should be presented to both sides frankly and clearly.

LUXATION OF THE TESTICLE

Luxation of the testicle (luxatio testis traumatica, dislocation, acquired ectopy) refers to an acquired malposition of the testicle. The relatively common congenital displacements have already been considered. Herbst and Polkey ('36) after an exhaustive review of the literature, were able to collect only 92 previously recorded cases to which they added one case of their own. McCrea ('38) reported a case in which spontaneous reduction occurred and cited another reported by Doe in 1937. The majority of these patients suffered dislocation following local trauma, although 15 of the series reported by Herbst and Polkey appeared to be associated with muscular efforts, while 7 patients so afflicted had practiced self-mutilation to escape military service.

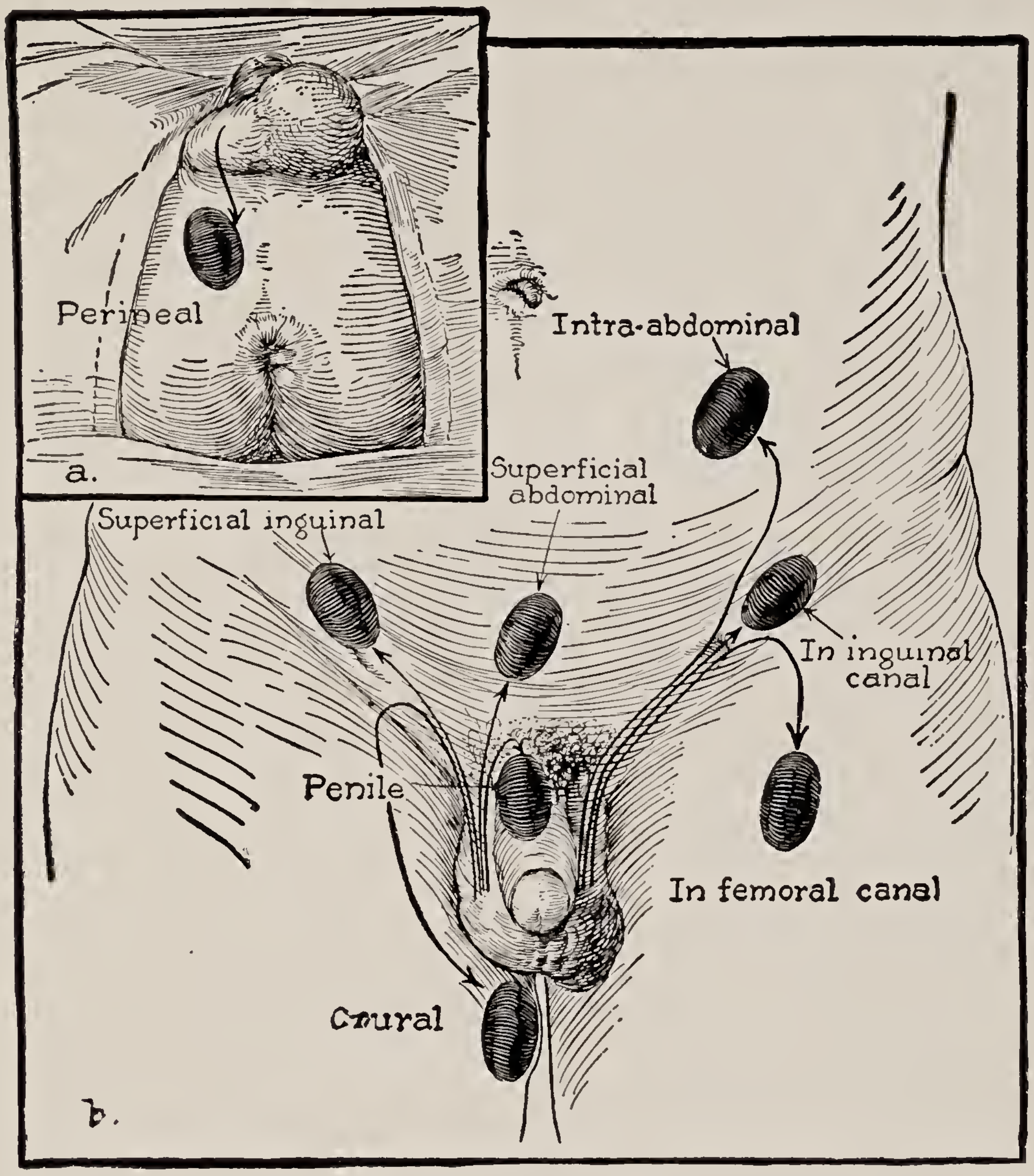

FIG. 11. Diagram illustrating deep or internal, and superficial or external types of luxation of the testicle. (After Alyea.)

These authors were able to produce luxation of the testicle experimentally in dogs, finding that great force was necessary to accomplish such displacement. They concluded that, in most instances, the three covering fasciæ of the testicle must be ruptured in order to allow luxation to occur.

Three types of acquired ectopy may be recognized (Fig. 11):

(a) External or superficial luxation — pubic, 11 cases; inguinal, 10 cases; perineum, 8 cases; penile, 4 cases; crural, 1 case.

(b) Internal or deep luxation — inguinal canal or abdominal cavity, 23 cases.

(c) Hernia or compound luxation of the testis in which the scrotal wall is ruptured with extrusion of the testicle through this rent, 27 cases. The majority of the patients so afflicted have been adolescents and young adults.

Treatment calls for immediate replacement of the organ in its normal position if atrophy is to be prevented. Surgery is usually indicated.

INFARCTION OF THE TESTICLE

It is convenient to divide the causes of infarction of the testicle into two groups, (1) infarction resulting from torsion of the spermatic cord and (2) infarction from other causes.

(1) *Torsion of the spermatic cord* (*torsion of the testicle, strangulation or volvulus of the testicle*) is the common cause of infarction of the testicle which leads to aseptic gangrene and finally to atrophy. It is purely a vascular phenomenon. Abeshouse ('36) collected 350 cases from the literature, but this condition is much more common than this number of cases would indicate. It is often mistaken for epididymitis.

a. **Etiology.** The common predisposing factors in the development of such torsion are anatomical anomalies, the most important of which are in relation to:

1. The testis: hypermotility, loose mobile connections between the testis and epididymis and between the scrotal contents and the tunica vaginalis.

2. The spermatic cord: abnormal attachments of the cord to the testis, a broad flat cord, a cord of excessive length, or bifurcation of the cord.

3. The tunica vaginalis: large size, absence or faulty development of mesorchium, or high investment of the tunica on the cord.

4. Miscellaneous causes: voluminous scrotum, elongation of the globus minor, abnormal range of motion of the vas, absence or faulty development of the gubernaculum.

The exciting force for torsion is thought to be strong contractions of the cremasteric muscle in association with heavy lifting, coitus, even mild strains such as turning over in bed or arising.

The average age of patients in the collected cases was 17.7 years, the large majority of torsions occurring before the age of 20 years. In a few cases the diagnosis was made shortly after birth, while 5 instances have been noted in men past 50 years of age. Probably half the cases have been in association with undescended testes (Varner and Green, '38), and 34 bilateral cases have been recorded (Abeshouse, '36).

b. **Pathological changes.** Torsions are divided into two groups depending on whether the twist is proximal to the tunica vaginalis, in which case the testicle and its tunics revolve as one mass (extravaginal), or whether the cord twists at a point between the proximal investing tunica vaginalis and the testicle (intravaginal), the testis revolving within the tunic. The latter is much the more common finding. The extravaginal type is more likely to involve the undescended organ.

The direction of the torsion is usually from without inward, clockwise on the right and counter-clockwise on the left. The degree of torsion may be from 90 to 360 degrees.

The effect of torsion of the cord is upon the veins which are first occluded, causing congestion of the tissues distal to the twist. Resulting edema or spasm may lead finally to arterial occlusion, and complete avascularity of the testicle and epididymis ensues. Pathological examination at this stage shows a congestive infarct. If the condition is not relieved, necrosis occurs, leading to atrophy of the organ.

c. **Diagnosis.** The onset is usually sudden, with acute pain in the testicle, following strain. The pain may radiate up the cord to the lower part of the abdomen or may travel into the thigh. Very soon, the testicle becomes swollen and the scrotum red and edematous. Mild constitutional symptoms frequently occur, including nausea and vomiting, accelerated pulse and a slight rise in temperature, depending on the progress of the necrosis. Examination shows an enlarged, exquisitely tender, retracted gonad. If the patient is seen before scrotal edema develops, the epididymis may be felt in an abnormal position in its relation to the testicle.

Prehn ('34) noted that, usually, in torsion elevation of the testis increases the pain, whereas in epididymitis it relieves the pain. A common finding is an empty scrotum on the affected side with a painful, tender mass in the inguinal region as a result of infarction of an undescended testis. Since hernia is so common in the latter condition, its differentiation from incarcerated or even strangulated hernia is important and often difficult. It must be remembered that torsion of an abdominally retained testicle occasionally occurs. A history of one or more similar attacks in the past is not unusual, detorsion having occurred spontaneously.

d. **Differential diagnosis.** If the entity of torsion of the cord is kept in mind, it will be diagnosed more frequently, with a corresponding decrease in the number of diagnoses of "traumatic epididymitis" or "epididymitis due to strain."

1. Acute epididymitis is most often confused with torsion. In epididymitis there is evidence of infection of the genital tract and the onset is usually not so abrupt. Prehn's sign may help the examiner.

2. The acute orchitis of mumps almost always is associated with primary parotitis, the pain is usually much milder and the cord is not involved.

3. Incarcerated or strangulated hernia must be considered, particularly as hernia is so often associated with cryptorchism.

4. Torsion of vestigial appendages of the testicle and epididymis usually runs a milder course than torsion of the cord, but differentiation is often very difficult. Since surgery is indicated in either case, the point is only of academic interest.

5. Acute fat necrosis of the scrotum (Hinman and Johnson, '39) runs a milder course. The pain is not affected by lifting the mass and occasionally a mass can be felt separate from normal testes.

e. **Treatment.** Every effort should be bent to save the testicle and this can only be accomplished by early surgical treatment. Manual detorsion has had little success. Unfortunately, even with early diagnosis few testicles have escaped final atrophy. If the cord is untwisted, and if, after the heat has been applied, the color of the gonad does not improve, orchidectomy is indicated. If an attempt is made to save the testis, orchiopexy should be done. Muschat ('31) advocates a hydrocele operation as well so that the testicle will adhere to the scrotum. It seems advisable to perform orchiopexy on the opposite side also, as a prophylactic measure to insure the continued presence of one functioning member for, even though an attempt is made to save the affected organ, its ultimate condition cannot be prognosticated at the time of surgery.

(2) *Infarction due to causes other than torsion of the spermatic cord.* Cedermark, in 1936, was able to collect 34 cases which fitted into this category, and to these he added 2 personal cases. Except for the mode of vascular occlusion, this type of infarction is similar to that caused by torsion of the cord. The majority are caused by primary or secondary thrombosis of the pampiniform plexus possibly following strain, trauma or infection. Most often no etiological factor is discovered.

Dorman ('38) reported necrosis of the testicle in 8 patients following surgery of the vesical neck. Four of these were probably caused by pressure on the funiculus at the pubis brought about by a tight suspensory worn following transurethral prostatic resection.

Since in most instances torsion of the spermatic cord can be ruled out only by surgical exploration, prompt intervention is indicated if the patient is seen early in the course of the vascular accident.

TORSION OF VESTIGIAL STRUCTURES OF THE TESTICLE

Colt, in 1922, was the first to publish a report of a patient upon whom he operated for torsion of the appendix testis. Since then, much interest has been evinced in this syndrome.

The inconstantly found vestigial structures of the testicle which may undergo torsion are: (1) the appendix testis, which is a remnant of the müllerian duct situated on the antero-superior surface of the testis, (2) the paradidymis or organ of Giraldés, which consists of rudimentary tubules of the paragenitalis, (3) the appendix epididymis, which arises from the tubules of the epigenitalis, and (4) the vasa aberrantia of Haller which are embryonic remnants of the wolffian duct situated in the epididymo-testicular groove.

Etiology. The cause of torsion of these structures is not known. It would seem that pedunculated, elongated or enlarged hydatids would be prone to undergo twisting of their pedicles. The large majority (85 per cent) of the reported cases have occurred before or at the age of puberty. Possibly, physiological changes taking place at that time may play a part. Randall ('39), however, suggested that the high incidence in youth arises from the greater ease of diagnosis because infectious lesions are a rarity at this age. Trauma and infection have been considered as possible causes.

Randall, in 1939, tabulated the reported cases (including 2 of his own) as follows:

Torsion of the appendix testis	75
Torsion of the appendix epididymis.....	2
Torsion of the organ of Giraldés	3
Torsion of the vas aberrans............	2
	82

Three of these occurred in undescended testes.

Diagnosis. Sudden acute pain in the testicle, developing for no apparent cause, is the leading symptom. In a very short time more or less edema and redness of the scrotum develop. General symptoms may be very mild, but are usually absent. In the course of a day or two the pain and swelling subside. It may then be possible to elicit point tenderness at the antero-superior pole of the gonad. Occasionally a small tender lump may be felt in this region. This is the only positive diagnostic finding (Roche, '35).

The diagnosis is easier to make in children than in adults. By appropriate methods, epididymitis, tuberculous involvement of the testicle, strangulated or incarcerated hernia, orchitis of mumps and torsion of the spermatic cord must be ruled out. The last differentiation is the most difficult (Lambert and Smith, '38).

The pain experienced with torsion of the spermatic cord is usually much more severe, of longer duration and accompanied by more swelling, and the constitutional symptoms are often marked. Whether the diagnosis is torsion of the cord or of a vestigial appendage, however, is not of great moment since immediate surgical intervention is indicated in either case.

Treatment. Immediate surgical operation is indicated because it (1) relieves the pain quickly, (2) prevents recurrent attacks and (3) allows exploration that settles the diagnosis and permits the surgeon to deal with a twisted cord which is so easily confused with torsion of a hydatid.

The operation merely calls for removal of the hydatid. Randall ('39) suggested suturing the testis to the edges of the incision in the tunica vaginalis in order that torsion of the cord may not occur later. He also felt that exploration of the other testicle should be carried out and elongated appendages removed for prophylactic reasons.

INFLAMMATION OF THE TESTICLE

Inflammations of the testicle, except the chronic form resulting from syphilis, are rare as compared to inflammatory conditions affecting the epididymis. Differentiation between processes affecting the testicle and those affecting the epididymis is a matter of clinical accuracy, but the report of gonorrheal orchitis, when the true process is epididymitis, is not unusual. Often it is difficult to determine whether infection starts in the testicle and spreads to the epididymis or vice versa. In general, gonorrhea and tuberculosis involve the epididymis first and rarely the testicle, while syphilis attacks the testicle and rarely the epididymis. These subjects are discussed elsewhere. A number of other conditions may be responsible for an acute or a chronic orchitis.

Acute orchitis is either an ascending type of infection from the posterior urethra by way of the lumen of the vas deferens through the epididymis, an epididymo-orchitis, or a metastatic type of infection by way of the bloodstream. Traumatic orchitis and orchitis from strain have been shown to be misnomers, and such inflammations are either ascending or metastatic in type, even though secondary to trauma.

Etiology. Acute metastatic orchitis is a frequent complication of many infectious diseases, and has been reported as such with typhoid and paratyphoid fevers, mumps, diphtheria, scarlet fever, variola, influenza, typhus fever, tonsillitis, dengue, glanders, malaria, filariasis, pneumonia, gout, acute articular rheumatism and Mediterranean fever. It also occurs as a complication of localized focal infection with pyogenic organisms — particularly *Bacillus coli* and Staphylococci — such as an apical abscess, sinusitis, furunculosis, osteomyelitis, cholecystitis or appendicitis. It is seen that almost any organism may enter the testicle through the blood and produce an acute orchitis or epididymo-orchitis. The general incidence is shown in Table I.

Typhoid fever. The severity of typhoid fever bears no relation to the incidence of orchitis. Usually both testis and epididymis are involved, and symptomatic hydrocele is not infrequent. Apparently suppuration may occur either as a toxic manifestation of a systemic infection or as the result of the local action of the organisms (Kinnicutt).

Variola. Statistics vary greatly as to the incidence of orchitis in variola, probably because of the difference in the virulence of epidemics.

Mumps. Mumps frequently is complicated by orchitis; in fact orchitis occasionally may form the whole symptom complex so that the parotitis is overlooked. Stengel stated that orchitis occurs in 18 per cent of all cases of mumps irrespective of treatment and, according to Laveran and Catrin, is bilateral in over a third of the

TABLE I

INCIDENCE OF ORCHITIS

Disease	*Author*	*No. of Patients*	*No. of Patients with Orchitis*	*Percentage*	*Bilateral*	*Suppuration*
Typhoid	McCrae	1500	4	0.27		
	Osler Liebermeister Sorel Hölscher	5500	14	0.25		
	Pierre Do	14738	0	0		
	Beardsley		102		3	22
Syphilis	Keyes	2170	67	3.08	10	
	Symmers	171 (acquired)	67	39.0		
Variola	Roger	55 (dead)	48			
	Quénu			90.0 (in severe forms)		
	Welch and Schamberg	2000	8			
Mumps	Laveran and Catrin		43	33.0	12	
	Osler	699	211	30.3		
	Stengel	32612		18.2		
Mediterranean Fever	Lombard and Béguet			5–6		
	Isaac			2–20		
Filariasis	Howard (1918)		14			7

cases. In 55 per cent of cases of orchitis from mumps, atrophy occurred, yet the occurrence of sterility or eunuchoidism appears to be extremely rare. Orchitis is most likely to occur in mumps coming on after puberty. One of our patients, who had orchitis with mumps, developed gynecomastia.

Tonsillitis. Orchitis secondary to tonsillitis is too rare to enter into statistical data, but cases have been reported by Verneuil, Lasègue, Joal, Prouty, and Benjamin and Quirk.

Malaria. Only in rare instances has malaria caused orchitis (Vecchia).

Pneumonia. Mills studied 60 testes removed from patients who died from pneumonia. While clinical orchitis was not mentioned, all the specimens showed considerable toxic degeneration.

Diphtheria. Bilateral orchitis with diphtheria in a boy aged 7 years was reported by Blechmann and Stiassnie. They were unable, however, to recover the organism from the testicle.

Typhus fever. Clinical evidence of orchitis does not seem to be a feature of this disease but 16 cases studied histologically by Wolbach, Todd and Palfrey showed lesions.

Filariasis. Elephantiasis is characteristic of filariasis, but Howard wrote that orchitis and funiculitis are common with the disease (Table I). In the cases in which suppuration occurred the patients were very ill, but all recovered after drainage.

Furunculosis and *osteomyelitis* rarely cause secondary septic foci in the testicle, but an instance of each was reported by Quénu and by Biland. Barney ('14) found no other reports.

Scarlet fever is very rarely complicated by orchitis, the only case reports found being those of Henoch and of Horteloup.

Acute articular rheumatism. Instances in which orchitis occurred with this disease were cited by Bouisson, Vache, and Dhomont. Medi reported a case occurring on the twentieth day in a child 3 years of age. Both testes were swollen. The left scrotum was incised and a little pus evacuated.

Gout. A few inconclusive cases were cited from the older literature by Monod and Terrillon.

Orchitis from an unknown source, or idiopathic orchitis, occasionally occurs with pyogenic cocci in the absence of a demonstrable focus elsewhere (DuBois, LeFur, Barney, Nash, Bonner).

Little has been written upon the histologic picture of testicular infections (Barney). In general, acute inflammatory processes manifest themselves between, not within, the canaliculi (Girode). There is generally more or less exudation into the tunica vaginalis. The testicle becomes enormously swollen and tender, and the scrotum red and edematous. The reaction, both local and general, is more severe than in epididymitis alone. The epididymis usually is involved with the testicle, and the cord may be thickened and sensitive (funiculitis). The process varies somewhat depending upon its causative factor. As a rule, multiple foci of infection occur in the testicle between the canaliculi, the tubules then degenerate and become filled with inflammatory exudate. Local areas of necrosis occur and become conglomerate. If the process goes on to suppuration, the whole testicle usually is involved, and orchidectomy is the only recourse. Suppuration occurs very rarely in mumps. Smith described the pathological changes of orchitis with mumps, Councilman those with variola, and Wolbach, Todd and Palfrey those with typhus fever.

Diagnosis. The greatest difficulty of diagnosis is the differentiation of acute primary orchitis from acute primary epididymitis. The differentiation is not always important, but should be attempted. As a rule, the onset is sudden and the pain severe, radiating to the back or the perineum. High fever, nausea and vomiting may occur. The speedy accumulation of fluid in the tunica vaginalis (hydrocele) may make differentiation by palpation impossible. Tapping the hydrocele during the acute stage for the purpose of diagnosis rarely is indicated, and is not without risk of spreading the infection. An acute infection of the testicle complicating an infectious fever is most likely an orchitis. The history and general examination readily differentiate, as a rule, an ascending type of infection which is primarily an epididymitis. In most cases there is an epididymo-orchitis. Of more importance is the possible confusion of torsion of the testicle or strangulated hernia with acute orchitis.

Treatment. Treatment should be expectant at first, care being taken to keep the scrotum elevated, and hot or cold applications should be used. In some cases of typhoid fever and mumps, multiple punctures of the testis and epididymis and drainage of the tunica vaginalis, may be advisable; as a rule, however, palliative treatment is all that is necessary unless suppuration occurs. Bonnamour and Bardin believe that the incidence of orchitis in mumps is reduced by giving an injection of 20 cc. of diphtheria antitoxin. Ballenger and Elder made longitudinal incisions through the tunica albuginea, in the orchitis of mumps, hoping to save the function of the testicle by releasing the increased pressure caused by the inflammatory swelling. It is often difficult to decide when surgical intervention is necessary, but certainly it is required as soon as fluctuation and suppuration are noted. (See Abscess.) In pyogenic infections, simple drainage may be insufficient if the whole testicle is badly involved, but the prognosis is always good so far as the life of the patient is concerned, and drainage may conserve part of the testicle.

Abscess of the testicle refers to suppuration of that organ, for which any of the causes of orchitis may be responsible, but analysis of the relatively few cases reported (Scudder, 1901, 32 cases; Caulk, '27, 15 personal cases) shows that the great majority are secondary to an epididymitis caused by an ascending infection by way of the vas or lymphatics. Thirteen of Caulk's patients had clinical evidence of epididymitis, and the other 2 cases resulted from surgical injury to the blood supply. Torsion of the cord has caused abscess (Ombrédanne, '13). Cultures usually show colon bacillus or staphylococci.

Treatment is by incision and drainage or castration. In 12 of Caulk's patients the lesion healed in from 2 to 6 weeks after incision and drainage. Early drainage prevents the extensive atrophy which otherwise results.

Chronic orchitis, as a clinical entity, manifests itself in two forms only: tuberculous and syphilitic. It is extremely unlikely that the testicle is ever involved primarily in tuberculosis but it is infected by extension from the epididymis. Massive tuberculous epididymo-orchitis may closely resemble gumma or tumor, both clinically and on gross section. In a personal case the testicle was considered malignant even after surgical inspection until microscopic examination proved it to be tuberculous.

SYPHILIS OF THE TESTICLE (GUMMA)

Etiology. Syphilitic orchitis is found in both congenital and acquired forms of syphilis, and manifests itself either as diffuse interstitial orchitis or as gumma. According to Herman and Klauder, the bone marrow and the testicle contain the *Treponema pallidum* before the appearance of the chancre. Nichols frequently failed to produce lesions other than of the testicle by means of intravenous inoculation of *Treponema pallidum* in rabbits. Warthin was frequently able to demonstrate the *Spirocheta pallida* in testicles presenting no gross lesion, and in cases of congenital and early acquired syphilis he found them in testes in which no histologic lesions could be found. He showed further that, in the autopsies of persons affected with syphilis, aside from the heart and aorta, the testicles were found most frequently involved. According to Weston, chronic fibrous orchitis is an almost constant finding in autopsies on those affected with paresis.

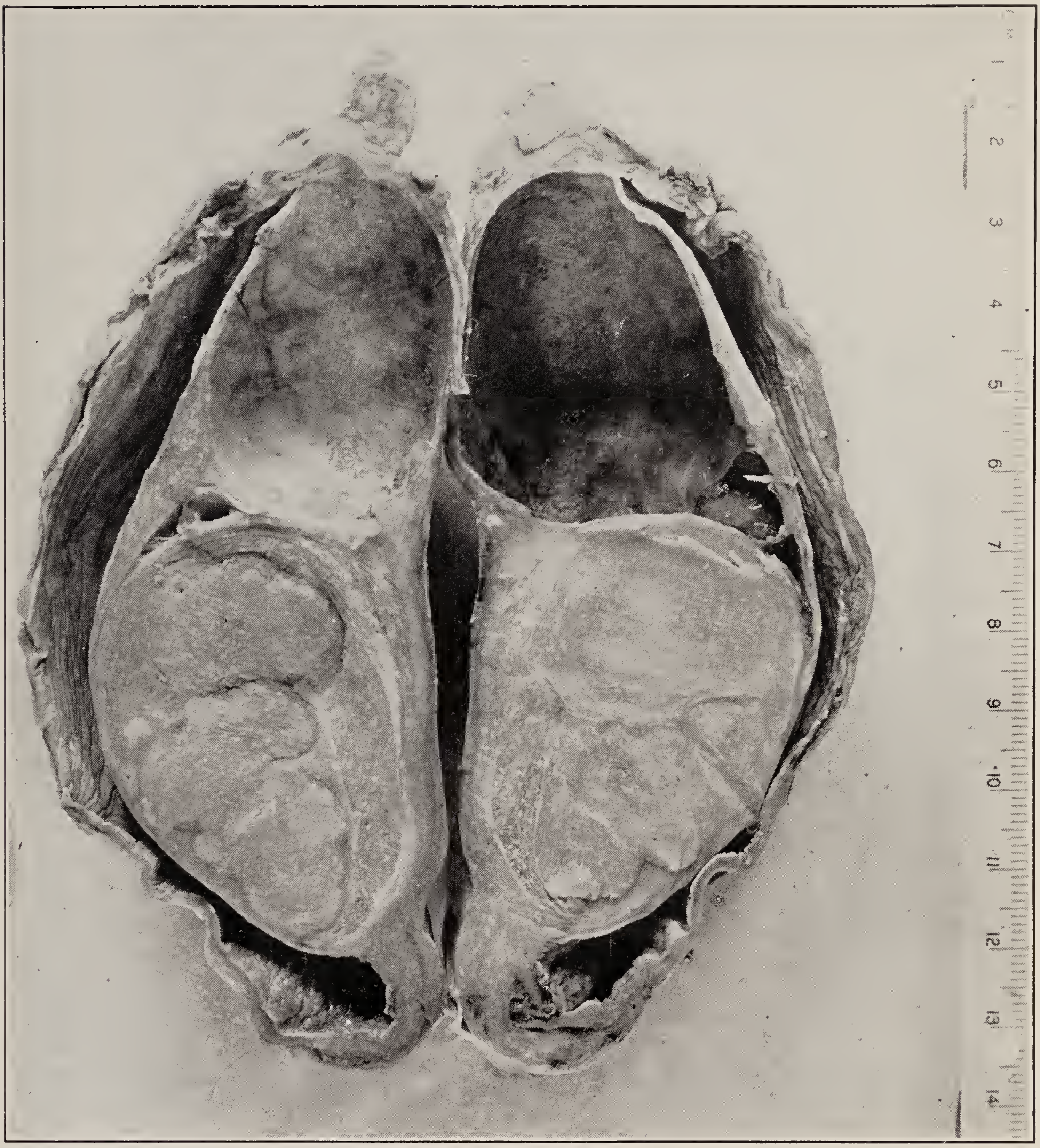

FIG. 12. Photograph of gumma of the testicle with a small hydrocele in association.

Pathological changes. The pathological changes in syphilitic orchitis are essentially microscopic and belong to the tertiary stage. They are characterized by a chronic interstitial fibrosis with or without the formation of gumma.

The frequency of testicular involvement in late acquired syphilis, as given by Symmers (39 per cent), does not seem to be borne out by clinical observation; but it must be remembered that most cases of syphilitic orchitis present no gross changes, and that clinical manifestations are limited to gumma, which is a comparatively rare complication of syphilitic orchitis.

Histologically there exists, in active cases of syphilitic orchitis, an infiltration of plasma cells and lymphocytes between the tubules about the smaller vessels, a proliferation of endothelial cells from the capillaries and fibroblasts from the stroma, with thickening of the basement membrane, tubular degeneration and decreased spermatogenesis. The changes may be diffuse or local. In localized orchitis, areas of healthy, fully functioning tubules are found. In late stages, the stroma between the tubules is thickened and hyaline, or the whole testis may be fibrous.

Grossly, the involved organ may be enlarged, globular, indurated and smooth (Fig. 12). If fibrous, it is smaller than normal and harder in consistency. In less pronounced cases the testis may be normal in size but induration is a persistent feature. Pathologically, the testicles of every person with syphilis may be said to be diseased, but in only a small percentage is the disease clinically demonstrable. Syphilitic orchitis may progress to loss of sexual desire and sterility without discovery of the condition.

As stated above, gumma rarely occurs in syphilitic orchitis, but it is sufficiently common to assume great practical importance in the differential diagnosis of tumor, tuberculosis and gumma. Gumma may be single or multiple. The testicle is enlarged, rounded, nodular or smooth, heavy and insensitive to pressure though the patient may complain of painful sensations in the organ, probably caused by traction on the cord or stretching of the surrounding tissue. Hydrocele of moderate size frequently accompanies gumma of the testicle. The epididymis is involved early, and even may be involved primarily in rare cases, without disease of the testis (Lisser and Hinman). Adhesions to the scrotum are not uncommon. Exceptionally, gummata break down and discharge cheesy matter; secondary infection with the formation of an abscess is then likely to occur. The process sometimes ulcerates through the scrotum, with the formation of exuberant granulations and prolapse of the seminiferous tubules in the form of an infected fungating mass of necrotic tissue (hernia testis). The breaking down may be followed by the formation of a chronic sinus. As a rule but one testicle is involved.

Histologically, it is well to recognize certain characteristic reactions, produced in the tissues by the Spirochete of syphilis, that will be of aid in differentiating between gumma and tuberculosis of the testicle, which sometimes cannot be diagnosed clinically or macroscopically. Even microscopically, the differentiation is sometimes difficult, but, in general, the vascular lesions are more or less characteristic and diagnostic in all manifestations of syphilis. There is always a marked infiltration of plasma cells and lymphocytes in the walls of and immediately surrounding the blood vessels, particularly the capillaries (Fig. 13). Coincidentally, there is dilatation of the capillaries, swelling and proliferation of the endo-

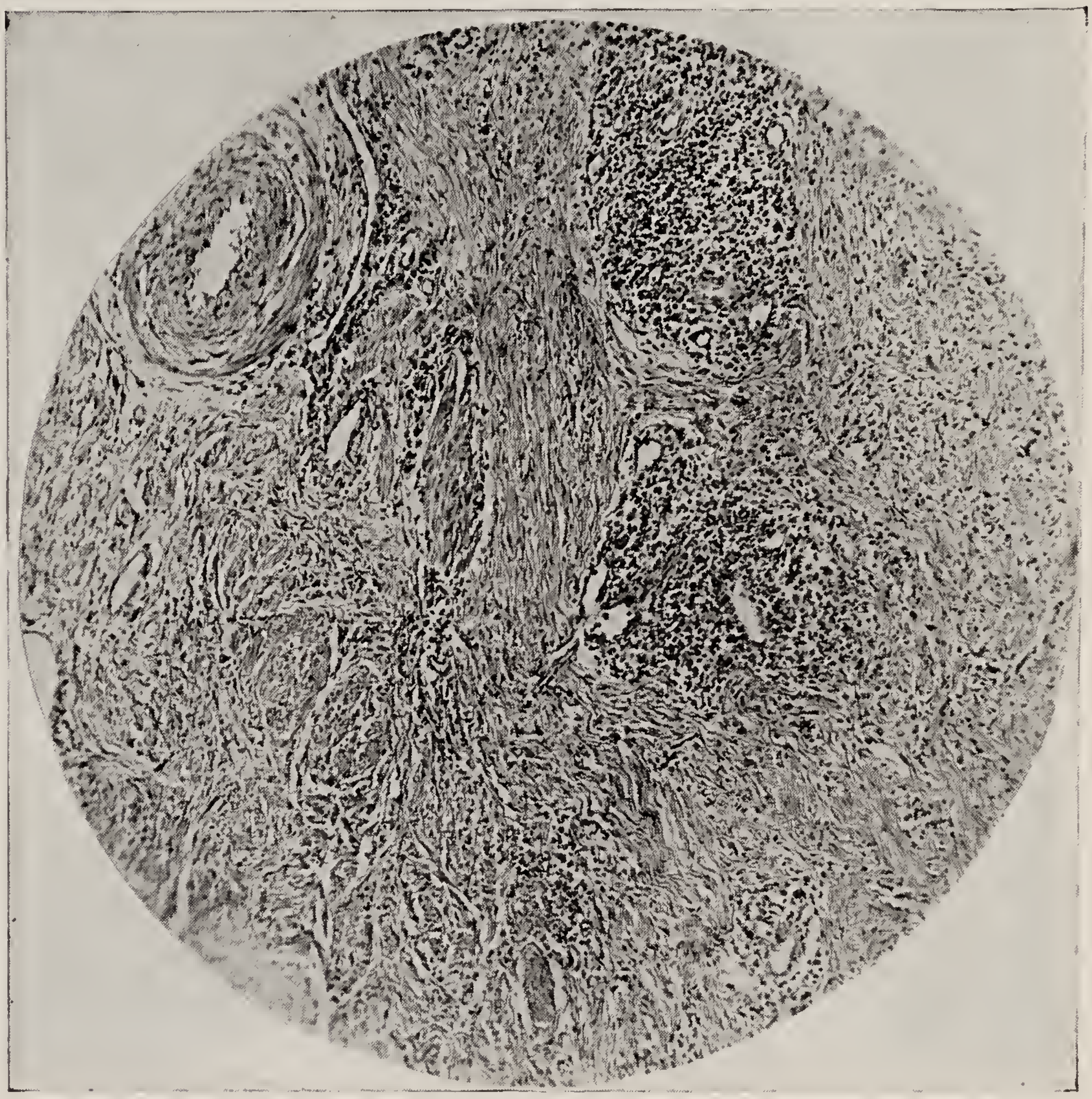

FIG. 13. Photomicrograph of a section from a gumma of the testicle. Note the marked perivascular lymphocytic infiltration.

thelium and formation of new capillaries. Congestion and fibroblastic reaction occur in the interstitial tissues. Here and there giant cells are seen, but they are by no means so constant a feature as in tuberculosis and are generally smaller. The exudate, by its action upon the capillaries, causes their thrombosis, and they are superseded by cords of endothelial (epithelioid) cells and occasional giant cells (Fordyce). Three types of syphilitic reaction are distinguished:

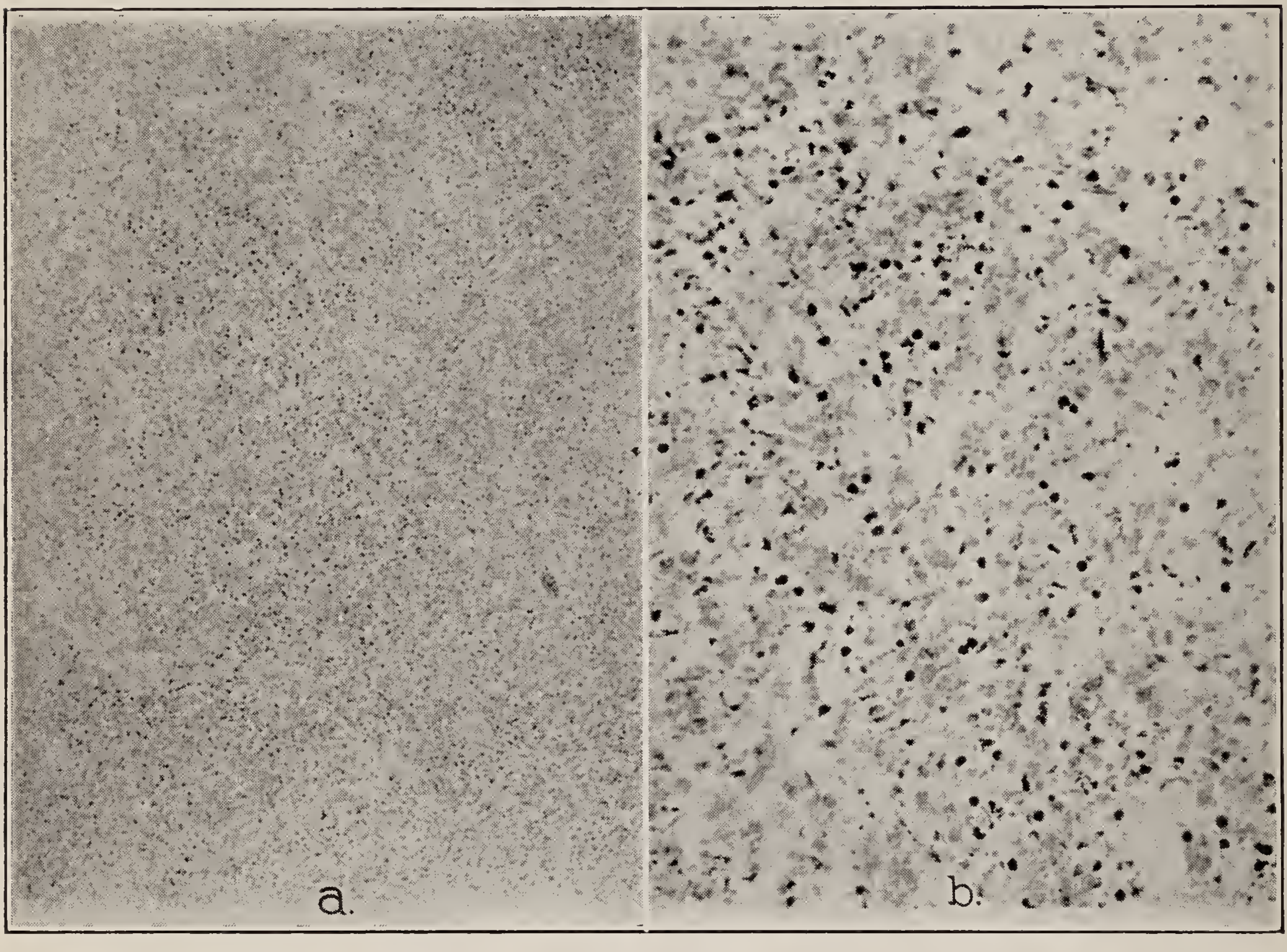

Fig. 14. Gumma of the testicle. The syphilitic gumma should not be confused with embryonal tumor of the testicle. (*a*, x 185; *b*, x 600.)

1. The diffuse exudate caused by an acute type of infection in tissues of low resistance, as in the visceral lesions of congenital syphilis. The whole testicle may be infiltrated, but there is no tendency toward localization or central degeneration (to form gumma).

2. The circumscribed localized exudates with no tendency to gummatous degeneration, but a marked tendency to spontaneous recovery, as in the ephemeral lesions of secondary syphilis.

3. The gumma of tertiary syphilis. The gumma is formed

TABLE II

DIFFERENTIAL DIAGNOSIS OF CHRONIC DISEASES OF TESTICLE AND EPIDIDYMIS

	Malignant Tumor	*Tuberculosis*	*Syphilis*	*Other Infections*
History	Perhaps trauma	Tuberculosis, family or personal	Syphilis, congenital or acquired	Gonorrhea, stricture, etc.
Cord	Normal	Enlarged and nodular	Normal	Thickened
Seminal vesicle	Normal	May be nodular	Normal	May be indurated and infected
Prostate	Normal	May be nodular	Normal	May be indurated and infected
Urine	Normal	Cloudy or clear	Normal	May be cloudy
Hydrocele	Unusual	Often	Nearly always	Unusual
Onset	Chronic	Chronic	Chronic	Acute
Age	Early youth and manhood	Early youth and manhood	Middle and later life	At any age
Veins (scrotal)	Enlarged	No change	No change	No change
Size	Large in advanced cases	May be large but usually small	May be large but usually small or medium sized	Fairly large
Frequency	Rare	Frequent	Frequent	Very frequent
Situation	In testis	Primary in epididymis (globus minor)	In testis as a rule, but may be primary in epididymis	Generally in epididymis but may occur in either or both
Palpation	May be smooth but generally nodular, with areas of fluctuation	Generally quite nodular and adherent, epididymis prominent	Smooth, hard, "billiard ball"	Smooth, firm or fluctuant
Growth	Fairly rapid growth	Slow	Slow	Sudden onset
Pain	Sometimes severe, usually absent	Slight	None	Severe
Scrotum	Normal	Normal or adherent	Normal	Red and edematous
Tenderness	None	Moderate	None	Marked
Course	Rarely suppurate	Marked tendency to suppurate	Occasionally suppurate	Frequency of suppuration varies, depending on cause
Bilateral	Very rare	Always in late stages	Occasionally	Occasionally
Fever	None	May be slight	None	High
Sexual power	Normal	Diminished or absent	Diminished or absent	Normal or increased (usually excluded)
Glands	Abdominal become involved	None	None	None
Atrophy of testis	Clinically never	Rare	Common	Common
Specific test	Aschheim-Zondek positive in 25 per cent of the cases	Intradermal tuberculin	Wassermann	Intradermal gonococcin

histologically by dense perivascular exudates, with central necrosis, similar to the caseation of tuberculosis, as a result of vascular obstruction about the periphery of the gumma. It receives its name from its gummy character, which results from the fact that the central area of necrosis is supported in a fibrous meshwork which does not permit liquefaction of the necrotic tissue, unless secondary pyogenic infection occurs (Fig. 14). Healing takes place either by complete encapsulation of the gumma or by its absorption and transformation of the area into a hard, contracted mass of scar tissue.

Tuberculosis differs from syphilis in the absence of perivascular exudate and new capillary formation, and in the preponderant reaction of epithelioid cells and formation of giant cells; in addition, the central necrotic mass does not exhibit the network of connective tissue which gives gumma its name.

Diagnosis. (See Table II, Differential Diagnosis.) Clinically, there is little to differentiate gumma from neoplasm or massive epididymo-orchitis of the testicle. With gumma, the Wassermann test is not always positive, and, even though positive, is only presumptive evidence, because syphilis and neoplasm may coexist in the same person. The Aschheim-Zondek test may facilitate the differentiation. If syphilis is suspected in a given case, a careful history and a physical examination for other stigmata of syphilis are necessary. If syphilis is diagnosed, the therapeutic test may be tried to determine the presence of gumma, but if there is no immediate response to treatment, operative exploration is indicated. In a doubtful case it is always better to remove a gummatous testicle immediately than to delay in the removal of a malignant tumor. Even though a gumma is mistaken for a tumor, and is removed, no harm is done, because the testicle probably already has been more or less completely destroyed by the gumma.

NEURALGIA OF THE TESTICLE

Etiology. Neuralgia of the testicle, aside from local disease, is relatively uncommon, but is of sufficient importance to have stimulated the contributions of Hammond, Terrillon, Roux, Patureau, Ultzmann and others. As early as 1830 Sir Astley Cooper, in his beautifully illustrated book, described the condition under the caption of "the irritable testis" and believed it to be a nervous affection akin to *tic douloureux*.

Monod and Terrillon distinguish three classes of neuralgia:

(1) Neuralgia without apparent local alteration in the gland.

(2) Symptomatic neuralgia dependent upon an active or healed lesion of the testicle or its excretory canal.

(3) Symptomatic neuralgia reflexly affecting the testicle from lesions outside the gland.

Class 1. The patient complains of a spot or localized area which is extremely sensitive so that the slightest touch may produce pain. This unnatural sensibility may endure for months or years, and resist all treatment. According to Monod and Terrillon, it is sometimes seen in children as a hysterical manifestation, or is the result of a spasmodic retraction of the testicle, " chorea testis." Prolonged sexual excitement without detumescence often causes neuralgia of short duration. Like idiopathic neuralgia and essential hematuria, its dignity as a distinct entity is more and more restricted by the recognition of its causative factors.

Class 2. Reference has been made to the comparatively insignificant lesions that occasionally result in atrophy of the testicle. Atrophic testicles, as well as those that are or have been at some time the seat of disease, are occasionally subject to neuralgic pains of more or less severity, and occasionally they are so intense as to cause the patient to seek relief by orchidectomy.

Class 3. Reflex pains from diseases involving other organs occasionally produce neuralgic pains in the testicle. Renal or ureteral calculus, diseases of the bladder, prostatitis and seminal vesiculitis, are likely to cause referred pains in the testis. Varicocele is an important factor in some instances. Hernia likewise has been reported as causing neuralgia of the testis. Hydrocele, adhesions of the tunica vaginalis, inflammatory occlusions of the vas or epididymis preventing egress of the testicular secretion, as well as extrinsic tumors, cysts, et cetera are possible factors in neuralgia. Sexual neuroses, with or without diseases of the genital organs, are often the basis of neuralgias of the testicle.

Diagnosis. In the history, the occurrence of trauma, gonorrhea, or inflammations involving the testicle, and, on local examination, the recognition of any abnormality of the testis, epididymis or vas as the result of past disease or injury, usually will show the causative factors. In some cases it may be difficult to establish a cause either as the result of local disease or as a reflex pain from disease elsewhere, in which case a neurotic or psychoneurotic basis for the condition should be investigated. It is indeed rare that a cause cannot be found.

TUMORS OF THE TESTIS

Introduction. Few subjects in medicine have been in such a continual state of flux as that of testicular neoplasm. A satisfactory pathological classification is still to be found because of the divergent theories of origin advanced by Chevassu and by Ewing. Concepts of treatment have changed. With the advent of more efficient roentgen therapy the need for radical surgical procedures is questioned. Debate still goes on, however, concerning the propriety of preoperative irradiation of the tumor. Finally, the significance of anterior pituitary-like substances found in the urines of many patients afflicted by testicular tumors is just beginning to be understood. The correlation of the clinical course, hormonal content of the urine and the pathological picture has added much to our understanding of these tumors.

Incidence. Testicular tumors are rare and comprise only about 0.57 per cent of all malignancies. The right testis is involved a little more often than the left. The relative frequency of tumor in undescended testes is difficult to estimate (Hinman and Benteen, '36). Many series of testicular neoplasms reported show from 11 to 13 per cent occurring in undescended testes, while others fall far short of this figure. The probabilities are that the ectopic organ is more susceptible to malignant degeneration than the normally placed organ.

Etiology. The causes of malignant changes any place in the human body are not known at the present time though many hypotheses have been advanced. It is apparent that no acceptable theory has been proposed to explain why a normal cell becomes malignant.

Origin of testicular tumors. There will be disagreement over the pathologic classification of testicular tumors until the origin of monocellular neoplasms is determined.

In 1696 Saint Donat described a testicular tumor containing fetal rudiments. Some semblance of order out of chaos was achieved by the epochal papers of Johnson (1856) who was first to recognize the tridermal constitution of testicular tumors, and those of Langhans who, together with Kocher (1887), laid the basis for an accurate classification of tumors according to microscopical structure. Wilms (1896) demonstrated that many testicular tumors are teratoid in origin.

Chevassu, however, after a careful study of 128 cases of testicular neoplasm, came to the conclusion that the monocellular tumors comprised of large cells in a light fibrous stroma containing few lymphocytes were in fact tumors derived from mature cells of the seminiferous tubules. No one can doubt the similarity of these cells on microscopic examination, but Chevassu was unable to demonstrate the transition between the normal and the tumor cell. He considered the small round-cell tumor with lymphoid stroma as but a more differentiated stage, and termed all of these tumors seminomas or seminal epitheliomas. Forty-six per cent of his series were of this type, 42 per cent were mixed tumors, 5.5 per cent were teratomas, while 5.5 per cent were miscellaneous tumors. Since this publication in 1906, disagreement on the pathologic classification of testicular malignancies has run rife.

Classification of Chevassu

1. Histoid tumors proper of the testis
    - *a.* Neoplasm of seminal epithelium (seminoma)
    - *b.* Neoplasm of interstitial cells
2. Connective tissue tumors of the testis
    - *a.* Fibroma
    - *b.* Sarcoma
3. Organoid tumors of the testis
    - Adenoma of testicle, usually in ectopic organs
4. Heterotopic tumors of the testis — intratesticular embryomas
    - *a.* Teratoma type — benign
        - (1) Encysted
        - (2) Simple
    - *b.* Mixed tumors
    - *c.* Simple embryoma
    - *d.* Embryoma with malignant degeneration
5. Secondary tumors (metastatic to testicle)

In 1911 Ewing, after careful histologic study of 19 testicular tumors, came to the conclusion that these neoplasms, almost without exception, arise from aberrant sex cells in the region of the rete and are teratomatous in nature. He postulated that the apparently monocellular seminoma is the end result of a teratoma the predominating cell of which outgrows and suppresses the other cell types or the cells of which differentiate along one line. In one mixed tumor he found areas of cells typical of seminoma; we have seen similar cases (Hinman, Gibson, Kutzmann). In another tumor he found chorioma, large-cell adenocarcinoma and diffuse carcinoma as well. Ewing's present classification, generally accepted in the United States, is:

1. Adult embryomas or teratomas (benign)
2. Embryonal teratoid or mixed tumors (malignant)
3. Embryonal malignant tumors (embryonal carcinoma)
4. Miscellaneous (rare)
    - *a.* Adenoma
    - *b.* Fibroma
    - *c.* Myoma
    - *d.* Sarcoma
    - *e.* Interstitial cell tumor
    - *f.* Lymphosarcoma
    - *g.* Adult multicystic adenocarcinoma (tumors arising from adult cells of seminiferous tubules)

His " embryonal carcinoma " is the same as Chevassu's " seminoma "; the difference is in etiology only.

Schultz and Eisendrath (1921) after a critical review of the literature and careful study of 15 personal cases, agreed with Chevassu that the common testicular neoplasm arises from adult spermatocytes but suggested the term " spermatocytoma " as more apt than " seminoma."

In 1925, Gordon Bell, attempting to prove the origin of these monocellular tumors from seminiferous cells, published some excellent photomicrographs which showed the close resemblance of the cells of some of these tumors to the cells of the seminiferous tubules. He concluded that tumors of this spermatocytoma group arise " from an uncontrolled proliferation of the seminiferous cells forming the glandular system of the testes in precisely the same way as carcinoma of other glandular organs."

In 1928, Stevens and Ewing also reported a monocellular tumor whose cells were almost identical in appearance with adult sex cells. They believed that 3 of Gordon Bell's cases were similar to theirs and designated them as " adult multicystic adenocarcinoma," believing that these rare tumors do arise from adult tubules and therefore are not embryonal carcinomata.

All authors, then, are in agreement upon the teratomatous origin of the chorionepithelioma, adenocarcinoma and the more differentiated mixed tumors containing carcinomatous or adenocarcinomatous elements. There is no disagreement about the group comprising the benign teratomata and dermoids or the rare miscellaneous homologous tumors arising from normal testicular cells (adenoma, fibroma, interstitial cell tumors, etc.).

The origin of the monocellular neoplasm, the most common tumor, is, however, under dispute. Ewing and his followers (Pick, Ribbert, O'Crowley and Martland, Hinman, Gibson and Kutzmann, Hinman, Johnson and Carr) believe that these are also teratomatous in nature, while the adherents of Chevassu (Frank, Schultz and Eisendrath, Bell, etc.) are just as certain that they arise from adult sex cells. Both groups have presented good evidence in support of their contentions but neither has as yet settled the problem satisfactorily. Fortunately, from the practical clinical standpoint, this is of no great moment since such knowledge would change neither the mode of treatment nor the judgment as to prognosis.

The Significance of Gonadotropic Hormone. Zondek, in 1930, was the first to report the presence of gonadotropic hormone in the urine of a patient suffering from tumor of the testis and, in 1932, he summarized the functional activity in 14 cases. During these years isolated instances of this biological phenomenon were reported in the literature, but it remained for Ferguson in 1933 to bring the subject to general attention by reporting on the functional qualities of 117 testicular neoplasms. Many of his patients had not been subjected to hormonal determinations before treatment was instituted and in those instances in which the tests were negative after therapy he assumed that originally they had been positive. He therefore erroneously concluded that all malignant tumors, including the small round-cell types, caused gonadotropic hormone to be excreted in the urine.

Unfortunately, much of the modern literature is still under the influence of this tenet, yet our rather extensive experience in the last 7 years shows clearly that not more than one-fourth of these malignant tumors provide a positive Aschheim-Zondek reaction. Recent reports of cases in the literature bear this out.

It is not surprising that tumors arising from immature sex cells should cause the elaboration of gonadotropic hormone typified by the reaction of pregnancy. It is also logical to expect that the amount of hormone excreted should vary in relation to the degree of differentiation of the functioning cells, which it does. As many as one million units of gonadotropic hormone per liter of urine may be found in patients suffering from chorionepithelioma, whereas the more differentiated carcinomas will be associated with little or no increase in hormone.

The source of the gonadotropic hormone in the urine of these patients has not been proved. In our earlier work (Hinman and Powell) we found that in some of the cases associated with abnormal amounts of anterior pituitary-like hormone in the urine, about five times the amount of hormone could be extracted from the tumor tissue, suggesting that the tumor itself excretes the hormone. Others, however, have assumed that testicular tumors secrete an unknown substance which stimulates the hypophysis to elaborate abnormal amounts of its gonadotropic substance.

The gonadotropic hormone is, however, a complex of several agents — each, when separated, giving its specific reaction. Evans isolated a follicle-stimulating (FSH), a luteinizing (LH), and an interstitial cell-stimulating hormone (ICSH).

Hamburger attempted to differentiate certain of the functioning testicular tumors by the type of ovarian response excited in test animals by the urines of affected patients. He claimed that the more differentiated tumors cause increased excretion of follicle-stimulating hormone from the pituitary gland, while the more primitive tumors themselves secrete a hormone which gives a chorionic (luteinizing) reaction. This supposition would be more convincing if hypophysectomized animals had been used for the tests, for it is only logical to expect that injections of high-unitage urine would contain all of the pituitary factors, and would accordingly produce both follicle-stimulating and luteinizing reactions. Hamburger's contention, then, scarcely seems tenable.

Melicow recently described a testicular tumor which clearly depicts the reason for the endocrine function of some tumors of the testis. His patient had gynecomastia and the urine was strongly positive for gonadotropic hormone. Photomicrographs of various sections from the tumor demonstrated typical blastula stages of many embryos. Irregular masses of syncytial cells resembling chorionic epithelium seen in pregnancy were clearly shown. Because of the latter finding, we consider this tumor a chorionepithelioma. No tumor in our series, however, has had this most unusual appearance.

Immature female rats or mice are utilized in tests for gonadotropic hormones; rabbits are insensitive to weakly positive urines.

Both gross and microscopic changes in ovary, uterus and vagina have been variously accepted as the index of activity. The use of different animals and different criteria in judging a positive response has led to variations in reports in the literature on the activity of similar tumors. Measurements should be quantitative, not qualitative. Progressive dilutions of the material (extract of the tumor, blood or urine) to the lowest limit of reaction measures the unitage of hormone. Concentration of the urine by extraction of the hormone from it is necessary in the estimation of a low content of hormone.

Dr. Herbert M. Evans, who is responsible for the urinary hormone assays carried out on our patients, routinely concentrates the urinary gonadotropin by the Levin-Tyndale method of precipitation with tannic acid, with some modification suggested by Dr. Levin. Normal immature female rats (25 or 26 days old) are used and two groups of three animals each are utilized for the tests. Over a period of four days alequot portions of powder derived from a known amount of urine are injected into each animal and autopsy is performed on the fifth day. A " positive " test is one which shows follicular or uterine stimulation.

Each animal of the first group is injected with the concentrated powder equivalent to 100 cc. of native urine. The rats of the second group are injected with the amount of powder derived from 4 cc. of urine. If these rats show no response, there are fewer than 10 Rat Units per liter of urine. If the animals comprising the first group show a " positive " reaction, while those of the second group are not stimulated, there are between 10 and 250 Rat Units per liter of urine. If both groups of rats react positively, there are over 250 Rat Units per liter and further tests are performed with varying dilutions of native urine.

By this method, normal males are found to excrete fewer than 20 Rat Units and usually fewer than 10 Rat Units per liter of urine.

It must be kept in mind that the estimation of gonadotropic hormone in the urine is a laboratory test only and is subject to inaccuracies. The urine of normal males contains a small amount of hormone the unitage of which varies according to the laboratory consulted, depending on whether rats or mice are used and upon the ages of the test animals. The presence of 300 units may be within normal limits at one clinic yet pathological at another. This precludes strict comparison of series of cases appearing in the literature. Conditions other than testicular tumor have been found which cause the production of increased amounts of hormone; these include cerebral tumor, acromegaly, increased intracranial pressure, hyperthyroidism, castration caused by surgery or roentgenotherapy and hypogenitalism (Owen and Cutler, 1936).

From the clinical standpoint, the value of the hormone test has fallen far short of what was expected of it initially. It has proved to be of little help in diagnosis but is of value in judging the prognosis. Periodic tests following surgery may afford information regarding the trend of growth.

Pathological changes. In our conception of the origin of testicular neoplasms we are convinced of the soundness of the theory of Ewing. One may look upon the teratoma of the testicle as a poorly developed " twin " arising in the host. This poorly developed twin is able to, and in most instances does, develop cancer arising from any of its primitive organs or tissues just as the developed twin (normal person) may do. From this logical conclusion, the following simple classification of testicular tumors is derived.

Clinico-hormono-morphologic Classification

A. Teratoma (benign, adult; dermoid) (rare)
B. Parenchymatous tumors arising in a teratoma
    1. Embryonal carcinoma without lymphoid stroma
    2. Embryonal carcinoma with lymphoid stroma
    3. Large clear-cell carcinoma
    4. Embryonal adenocarcinoma
    5. Chorionepithelioma.
C. Tumors arising from normal cells of the testis (rare)
    1. Fibroma
    2. Adenoma
    3. Interstitial cell tumor
    4. Myoma
    5. Lymphosarcoma
    6. Sarcoma.
D. Metastatic tumors (rare).

The embryonal carcinomata with and without lymphoid stroma are also known as seminoma (Chevassu), spermatocytoma (Schultz and Eisendrath), malignant seminocarcinoma (Melicow), dysgerminoma (Meyer), and small round-cell sarcoma.

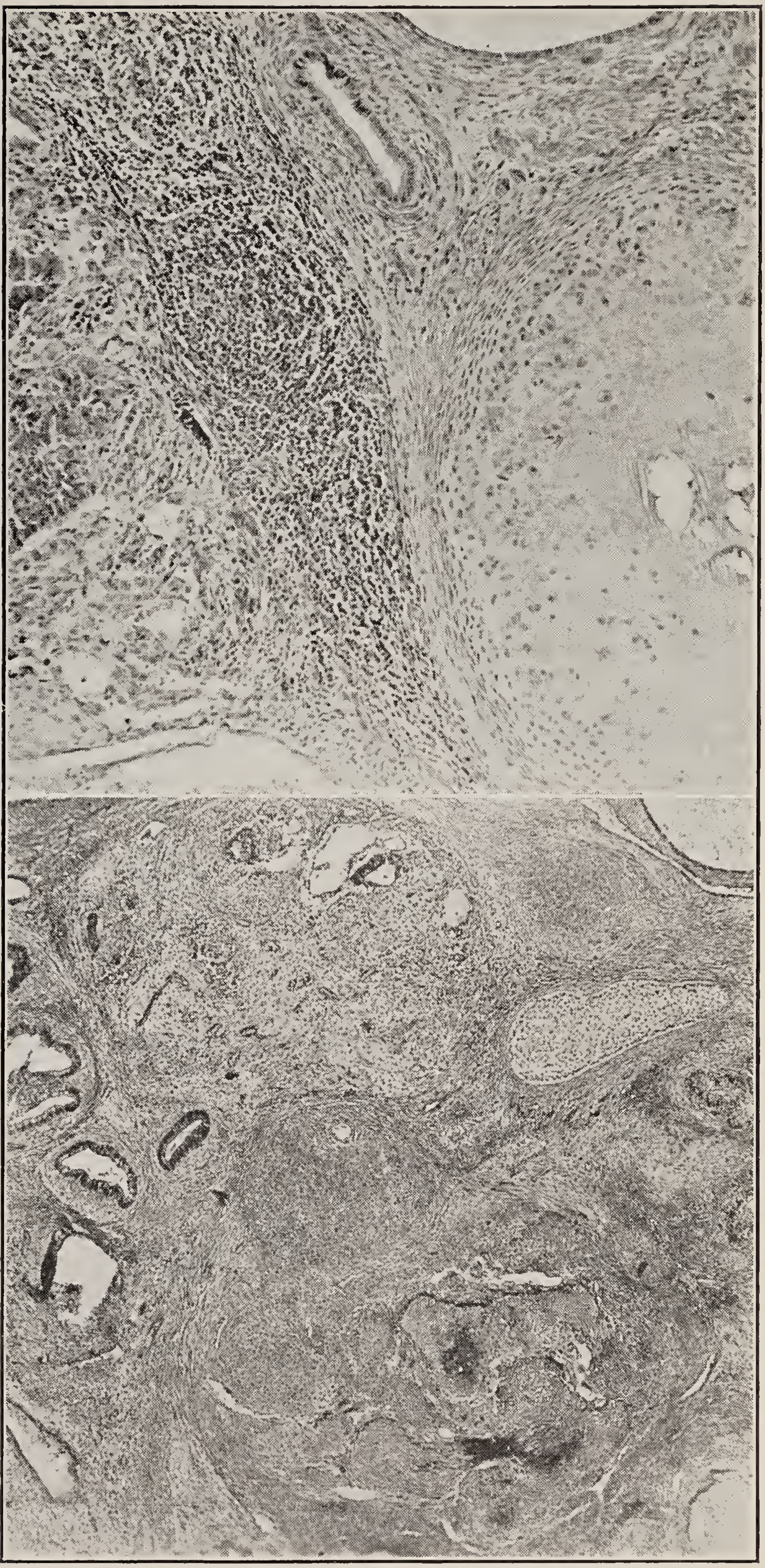

FIG. 15. Tridermal elements of adult teratoma, non-malignant. Note cartilage, simple cysts, gastrointestinal epithelium, tooth buds, nerve tissue and other mesenchymal cells.

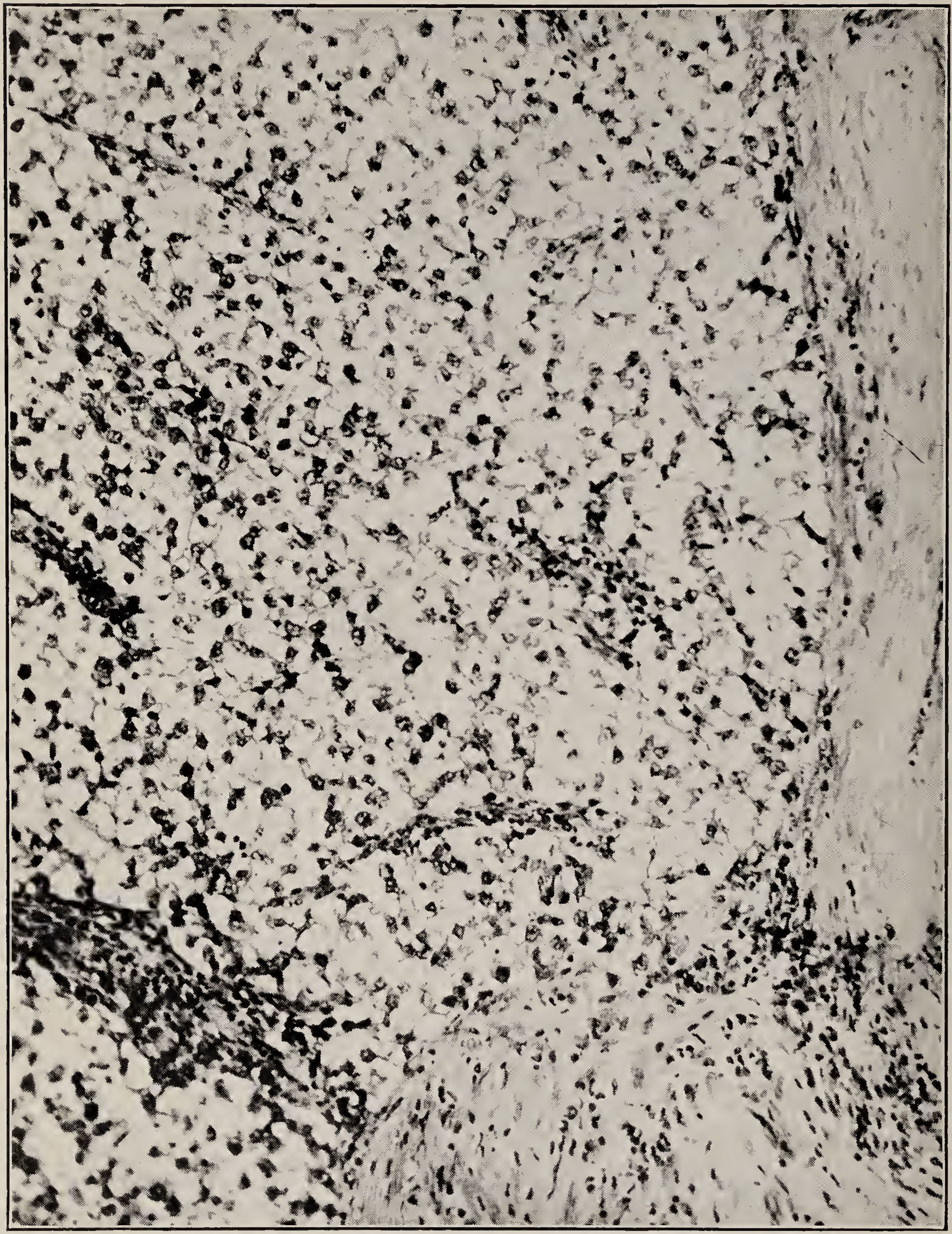

FIG. 16. Embryonal carcinoma with lymphoid stroma just developing. Small round cells lying in a light reticulum. No hormone.

The adult, benign teratoma or dermoid is very rare. These tumors are comprised of tissues of all three germ layers. Almost

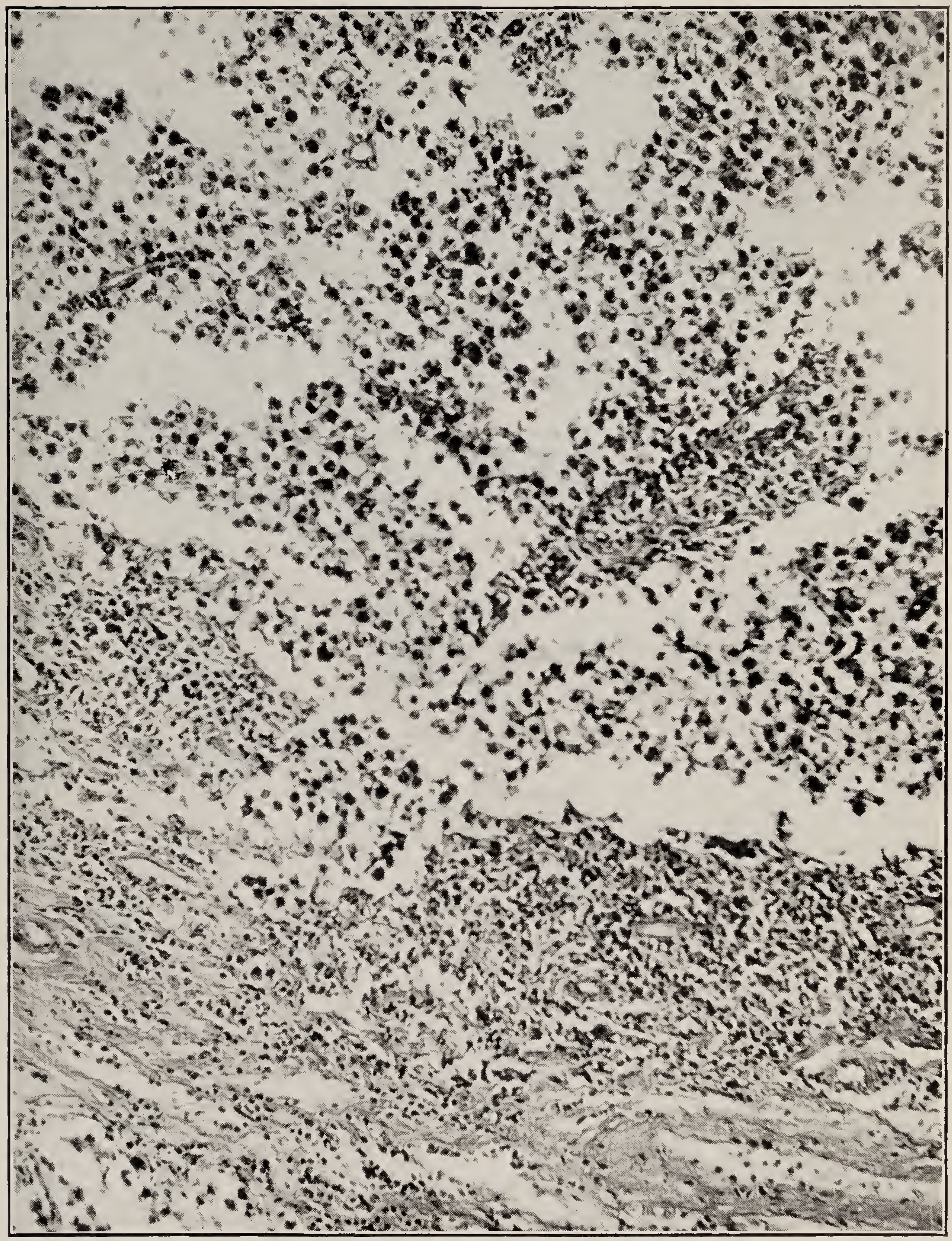

Fig. 17. Embryonal carcinoma with lymphoid stroma fairly well differentiated. No hormone.

all tissues have been identified in them, including thyroid, bronchial and intestinal epithelium, hair, teeth, cartilage, nerve, etc.

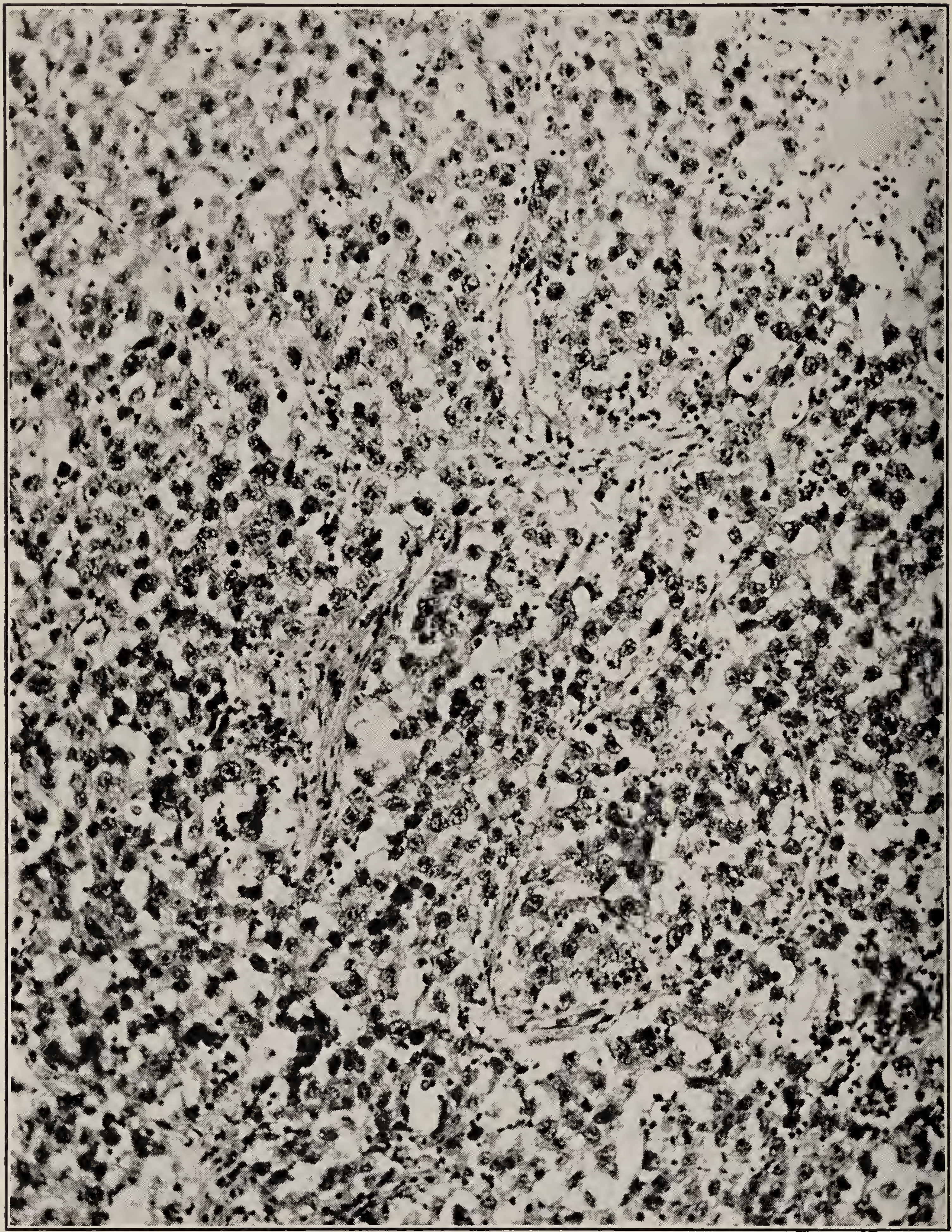

FIG. 18. Large clear-cell carcinoma, less differentiated and more malignant than embryonal carcinoma. Nuclei are pale except for dark nucleoli. May excite hormone excretion.

(Fig. 15). The body of an embryo may be found in a dermoid cyst. A diagnosis of benign teratoma is not tenable unless serial sections of the tumor are made which show no malignant tissue. Even then the diagnosis should be made with reservation. These tumors have no endocrine function.

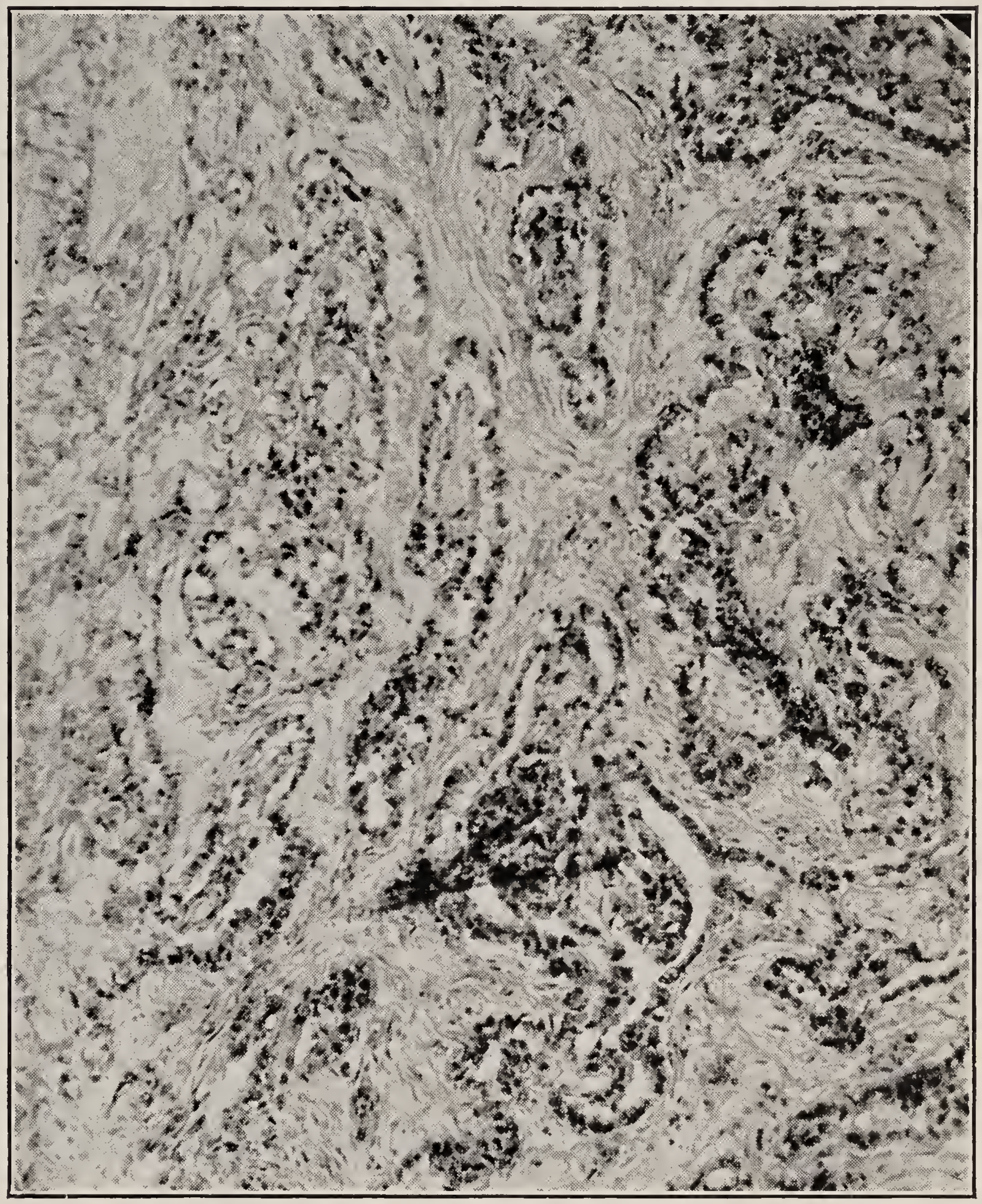

Fig. 19. Well differentiated adenocarcinoma. No hormone.

The grouping of parenchymatous tumors arising in teratomas into monocellular and mixed cell types is no longer practical and only confuses their classification. All these tumors are of the same family, showing transitional stages of development only. The most primitive cell or group of cells distinguishes the particular class of the tumor whether this type makes up the whole of a mon-

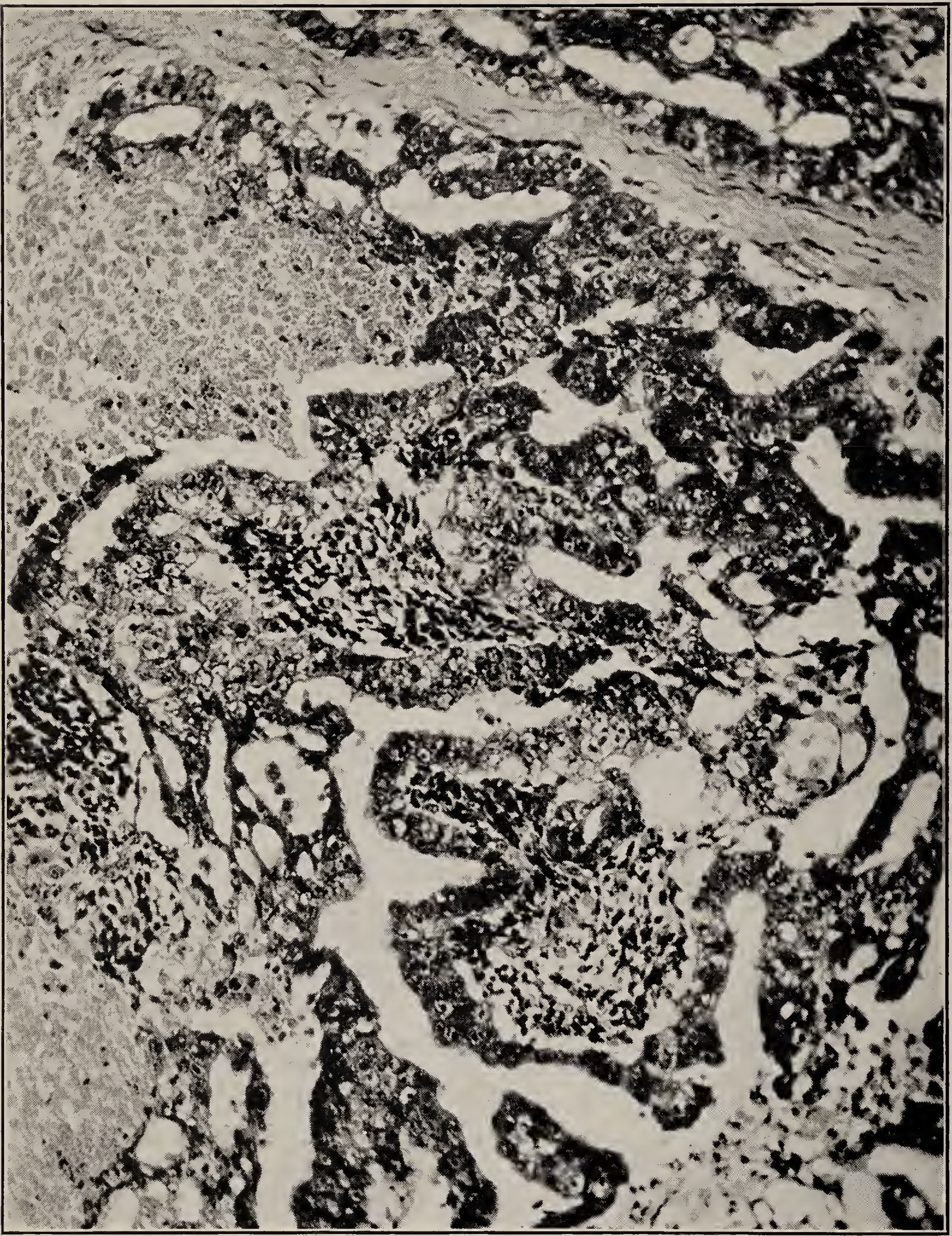

FIG. 20. Less differentiated adenocarcinoma of papillary type. No hormone.

ocellular growth or a very small part of a teratoma or mixed growth. The recognition of embryoma as opposed to adult mature characters is the important distinction in classification.

Of the parenchymatous tumors arising in teratomas of the testis, the most common and the least malignant is the embryonal carcinoma. This is a soft, rapidly growing tumor which commonly undergoes central necrosis. Hemorrhage, therefore, is not unusual. Histologically, this neoplasm is monocellular in type almost without exception (Figs. 16, 17). There are two types:

The embryonal carcinoma without lymphoid stroma is a well-differentiated tumor and its cells resemble those of adult seminal epithelium. Histologically it is typified by large, pale, round or polyhedral cells of almost monotonous uniformity lying in a light fibrous stroma containing only a few lymphoid cells. The tumor cells occasionally assume an alveolar arrangement. Many mitotic figures are seen. This tumor is relatively rare.

The embryonal carcinoma with lymphoid stroma is also fairly well differentiated and is the most common type of neoplasm of the testis. It is composed of sheets of small dark-staining cells lying in an abundant lymphoid stroma composed of immature fibroblasts.

In our experience only one-fourth of the embryonal carcinomas excite the elaboration of abnormal amounts of hormone, and in these cases there are fewer than 1000 Rat Units per liter of urine.

The large clear-cell carcinoma is uncommon, is not so well differentiated as the foregoing tumors, and is probably more malignant. Microscopically, the tumor consists of closely packed cells with large pale nuclei containing dark nucleoli laid out in sheets lying in a light fibrous stroma. They resemble the Langhans type of cell (Fig. 18). The urinary hormone is low or normal.

The second most common tumor is *the embryonal adenocarcinoma;* most adenocarcinomata are well differentiated. The rare primitive adenocarcinoma is very malignant and a high unitage of testicular neoplastic hormone is found in the urine. In such cases more careful study of the primary tumor, as well as autopsy material, will show chorionepitheliomatous elements. We have seen this demonstrated on two occasions.

The differentiated type is less malignant, and in fewer than 20 per cent of patients are abnormal amounts of hormone found in the urine. Histologically, the adenocarcinoma does not differ from that seen in other epithelial structures (Figs. 19, 20, 21).

Chorionepithelioma is the most primitive of the testicular tumors, is therefore the most malignant and, as might be expected, excites the excretion of large amounts of gonadotropic substances

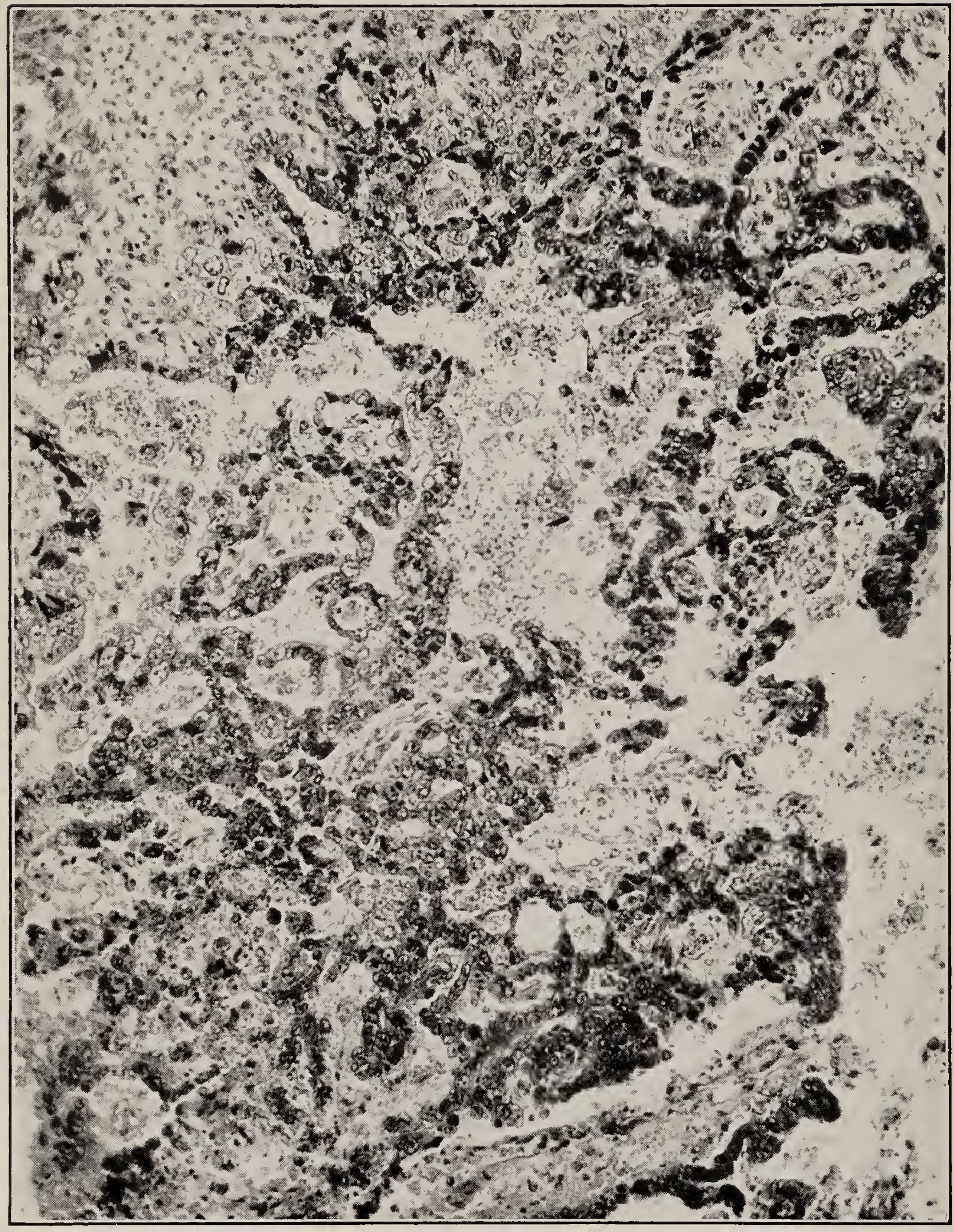

FIG. 21. Primitive type of adenocarcinoma differentiating toward the chorionepithelioma type. Hormone usually present.

in the urine. It is similar to the chorioncarcinoma in the female. Only three cases have been reported in the literature in which "cure was obtained"; one report was not accompanied by a photomicrograph and the other two patients had been living less than one year at the time of the report. The female appears to have more resistance to syncytial cells since cures of chorioncarcinoma in women, even in the presence of metastases, have been reported.

Judging from the literature, this tumor is rare, but of our last 44 cases of testicular neoplasm, 6 were chorionepitheliomata. In two, the primary tumor failed to show cells typical of this tumor but the clinical course and the amount of urinary hormone (100,000 RU per liter or more) suggested the proper diagnosis which was proved at autopsy in both instances. A third patient had no palpable nodule in the testicle but presented a large retroperitoneal mass and gynecomastia. Two hundred thousand Rat Units of hormone per liter of urine were demonstrated, and biopsy of the mass showed chorionepithelioma. It is therefore suggested that this tumor is not rare and that despite the histologic appearance of the primary tumor, the presence of more than 10,000 or certainly of more than 50,000 Rat Units of gonadotropin per liter of urine is diagnostic of chorionepithelioma. It also suggests the necessity for study of many sections from the primary tumor since the primitive area may be missed on cursory examination.

The tumor is often small and may be overlooked or it may not be demonstrable by palpation, the symptoms arising secondary to metastases (Fig. 22). Histologically, the tumor consists of undifferentiated carcinoma with large pale cells (Langhans type) showing many mitoses and masses of syncytial cells which typify it (Fig. 23).

The tumors arising from cells normally found in the male gonad are rare, as are secondary tumors. They, of course, do not cause the excretion of abnormal amounts of gonadotropic hormone in the urine.

Table III graphically indicates the amounts of gonadotropic hormone which may be expected in association with the various tumors. It must be remembered that this chart is based on our own experience with one standard method for the determination of hormone. Identical figures will probably not be obtained at other clinics but the same relative results should be obtained.

Testicular tumors usually metastasize first by way of the lymphatics to the retroperitoneal lymph nodes along the aorta and vena cava, whence they may progress to the mediastinal and supraclavicular nodes. Involvement of inguinal nodes occurs only if the

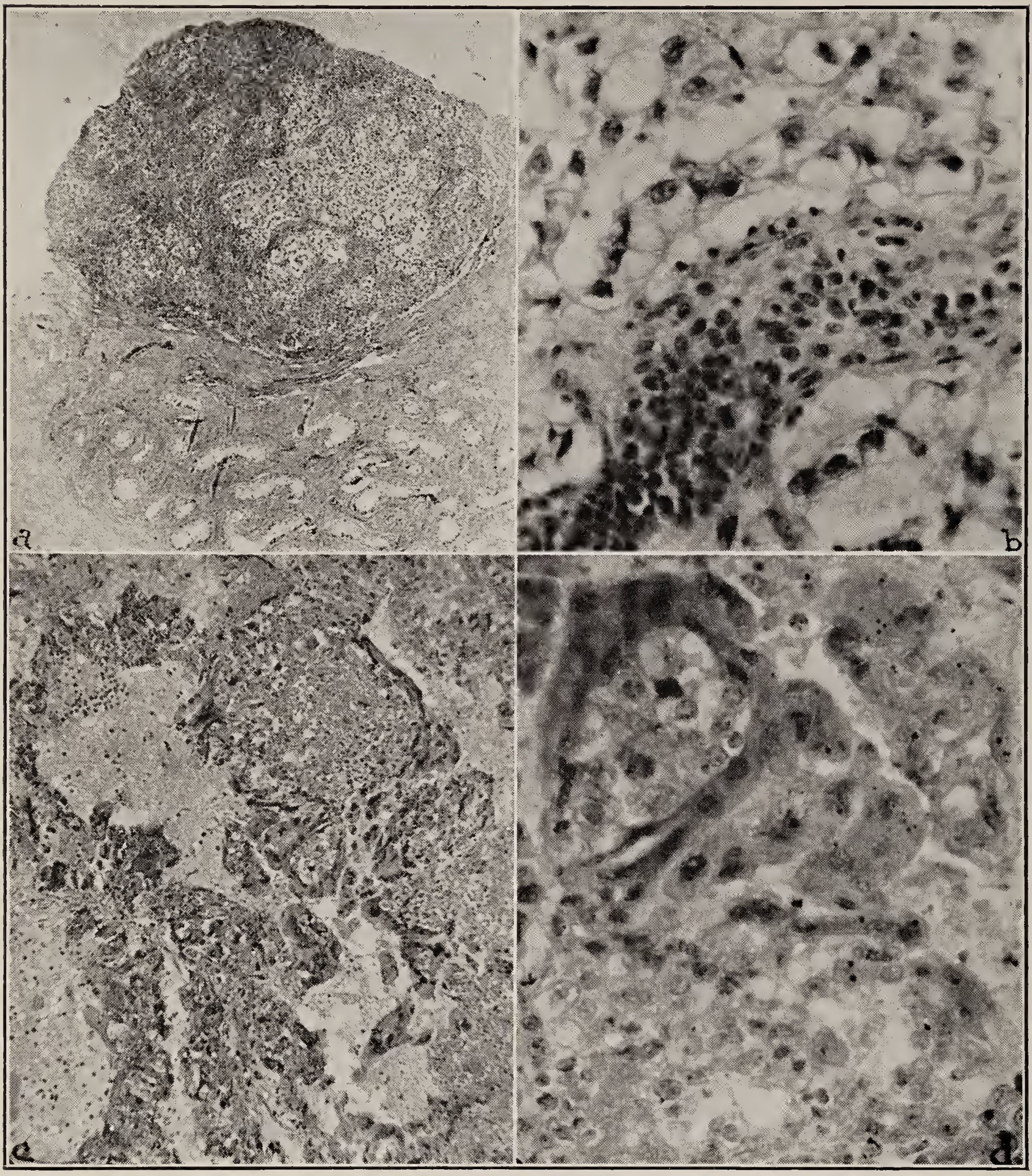

Fig. 22. Transition of character between minute primary tumor and metastases. *a*, Total primary growth showing typical embryonal carcinoma with lymphoid stroma, but patient had over 100,000 Rat Units of hormone per liter of urine, yet no chorionic elements are present. Low power. *b*, High power view showing large cells in light reticulum and strand of lymphoid stroma. *c*, Metastatic tumor of lung. Note areas of hemorrhage and necrosis, few Langhans cells and many multinucleated syncytial cells. Chorionepithelioma. Low power. *d*, High power view of metastatic tumor showing typical chorionepithelioma.

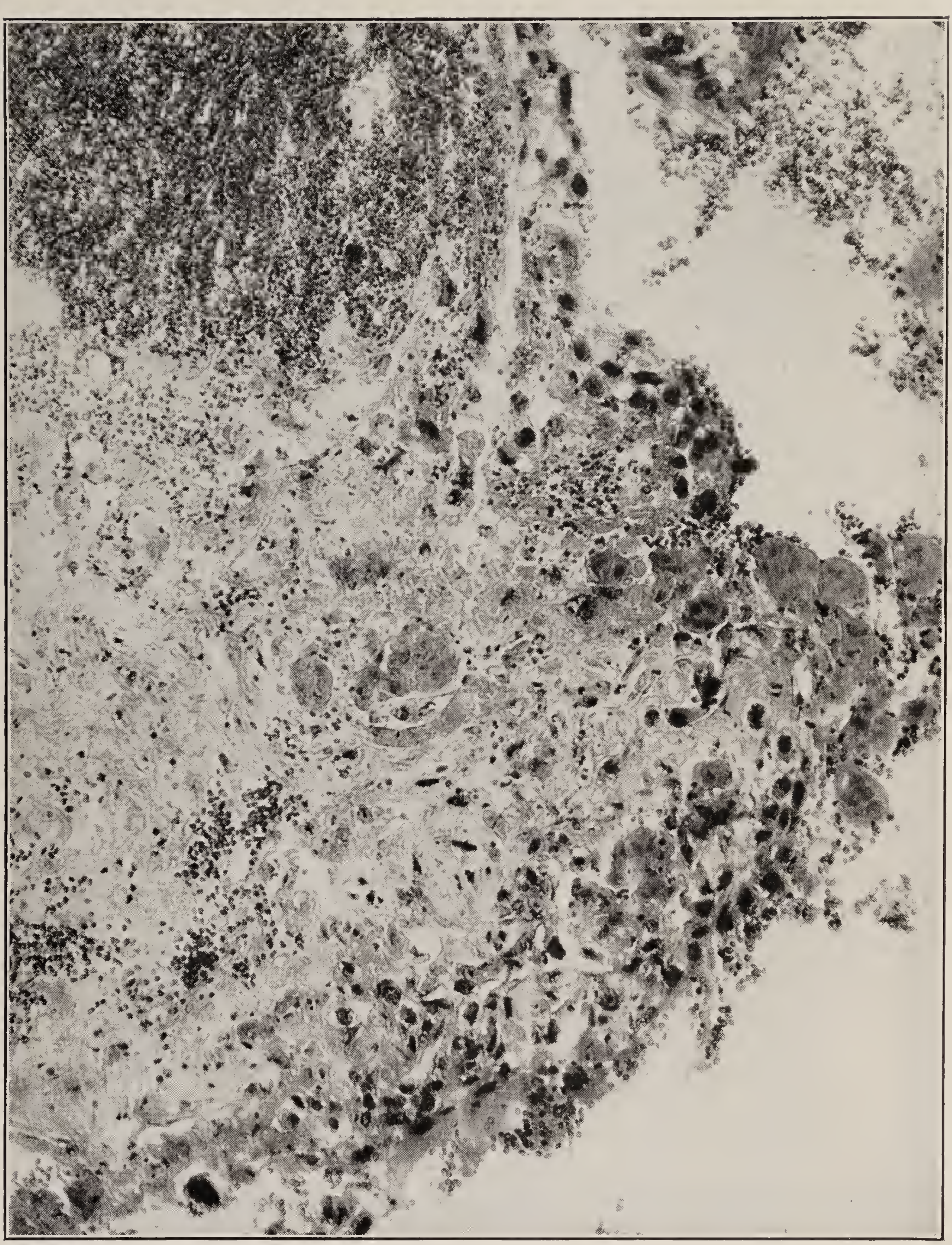

FIG. 23. Chorionepithelioma. Langhans cells more deeply staining than usual. Note multinucleated syncytial cells. High hormone.

scrotal wall has been invaded by cancer. Discontinuous metastases along the veins are commonly observed in the lungs and may also be seen in the liver, brain, kidney and stomach. Occasionally continuous invasion of the veins may occur, with cords of tumor cells extending all the way to the heart.

Usually the metastatic cells are similar to the most primitive type of cell found in the primary tumor, but at times chorionepithelioma is found in metastatic tissue though not demonstrated in the gonad itself.

Symptoms and Signs. Most patients first notice a painless enlargement accompanied by a sense of weight or fullness in the scrotum. Pain is unusual but may occur following hemorrhage into the tumor. The presenting symptoms of a few are referable to other organs affected by metastases; the primary neoplasm may be discovered only incidentally.

TABLE III

Type of Tumor	*Rat Units of Gonadotropin per Liter of Urine*							*Hormone Response*	
	Neg.	50	500	1000	10,000	100,000	1,000,000	Pos.	Neg.
I. Teratoma, benign	Neg.								1
II. Parenchymatous tumors									
A. Embryonal carcinoma without lymphoid stroma B. Embryonal carcinoma with lymphoid stroma	X——	——	—X					5	16
C. Large clear cell carcinoma	X——	——	——	—X					1
D. Adenocarcinoma	X——	——	——	—X				3	12
E. Chorionepithelioma					X——	——	—X	6	
							Total	14	30

Hormone response in the last 44 cases of testicular tumors.
The 14 patients having increased hormone are dead.

Tumor of the testis is a disease of early adult life, the majority occurring between the ages of 20 and 40, though they are seen from birth to old age. Mixed tumors are the rule in children, monocellular types being very rare (Kutzmann and Gibson, '23).

The onset of testicular tumor is usually insidious and its tendency toward showing periods of latency in growth renders uncertain the estimation of duration before the diagnosis. As a rule, the tumor grows rapidly and has been present less than one year when the patient is first seen. More slowly growing tumors, such as the adult teratoma and an occasional seminoma, may have existed several years, although rarely over three or four, before inducing their bearers to seek medical advice.

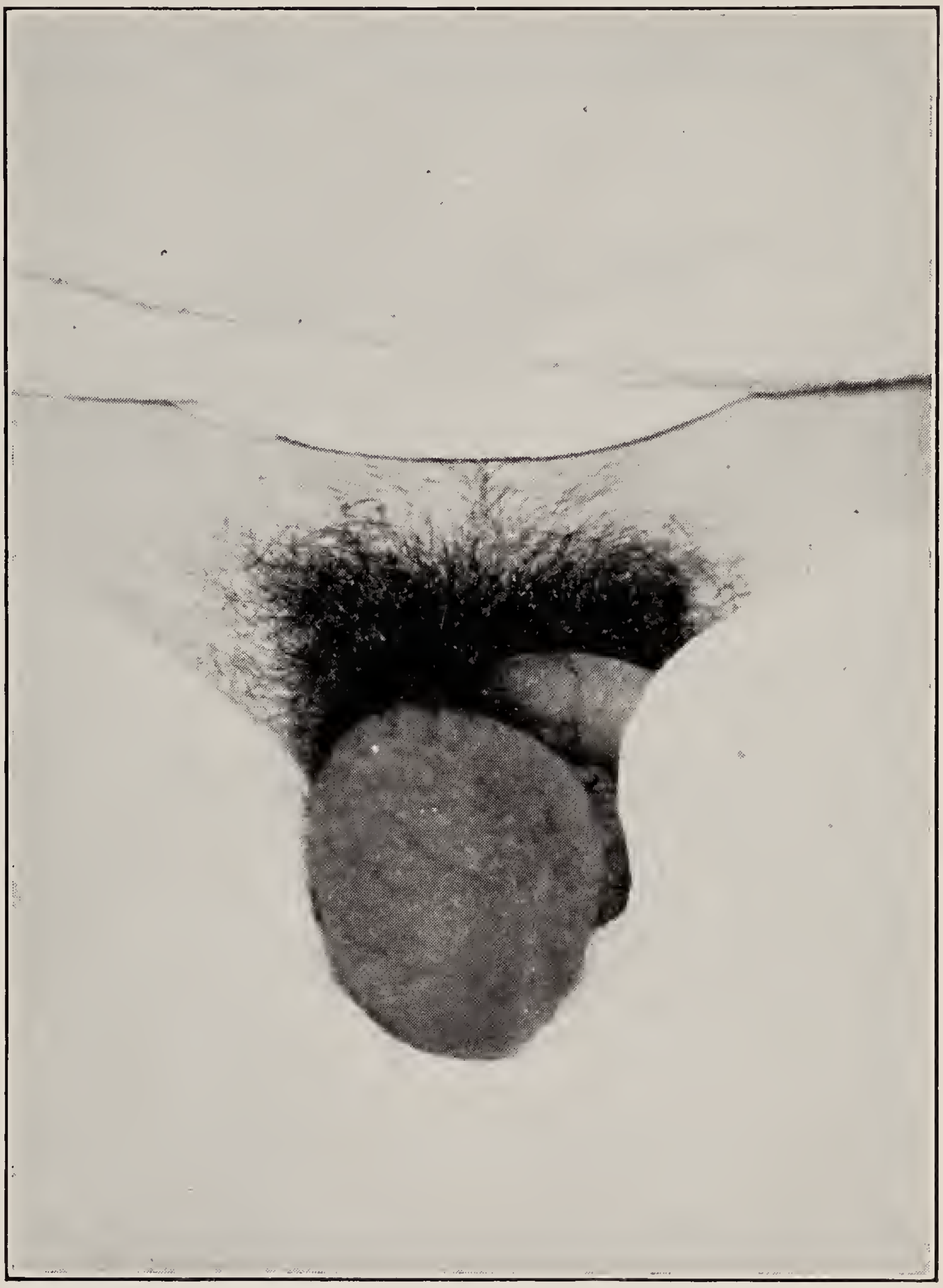

FIG. 24. Photograph to show the preservation of the shape of the testicle with enlargement caused by tumor. This tumor proved to be a typical embryonal carcinoma.

On palpation, which should be gentle, the new growth usually is found to preserve the shape of the testicle, being limited by the tunica albuginea (Fig. 24). It suggests an abnormal sense of weight. The epididymis is recognizable when the growth is seen early but later it is lost in the enlargement. In early stages the tumor is usually firm in consistency, without stony hardness and its surface is smooth and regular. Nodules and irregularities of variable size and consistency as well as softening and fluctuation over areas of cystic degeneration occur, but are usually late. Occasionally a sudden onset and rapid course simulate an acute inflammatory reaction. Seldom are these tumors sensitive to pressure. Hydrocele is not uncommon in association with testicular neoplasms. The skin of the scrotum is freely movable over the mass although it may appear red and glazed from being stretched. Dilated veins may be easily seen in its wall. Involvement of the scrotum by tumor is a late manifestation and fortunately is rarely seen now. The spermatic cord may be thickened by the weight of the tumor but not by invasion until very late. Metastasis to the inguinal nodes is secondary to involvement of the scrotal wall and is therefore rare.

Careful palpation of the abdomen for metastases is essential and a roentgenogram of the chest should be routine. Virchow's node should be sought for as well.

Whenever tumor of the testis is suspected the urine should be tested quantitatively for gonadotropic hormone; a positive test is diagnostic, but a negative test is of no significance as far as diagnosis and treatment are concerned.

Differential diagnosis. A tense hydrocele may simulate tumor, but the flashlight will differentiate from neoplasm all but the thick-walled type. Aspiration will be diagnostic in difficult cases, but it must be remembered that tumor may be associated with hydrocele.

Gonorrheal and nonspecific epididymitis in early stages may present a testicular mass the two organs of which are indistinguishable from one another. Signs and symptoms of infection of the lower tract can be demonstrated, however, and the mass is usually associated with severe pain and tenderness and a febrile reaction.

Tuberculous epididymitis may suggest tumor if the testes also become involved. In tuberculosis, however, the vas is ordinarily nodular, and the prostate and seminal vesicles may be so. Tubercle bacilli may be recovered from the urine. Moderate pain and tenderness usually accompany tuberculous epididymitis.

Gumma may give rise to some difficulty in the differential diagnosis of tumor since both afflictions involve the testis primarily and are ordinarily painless. Hydrocele is very common in association with gumma and the Wassermann test is usually positive. The administration of iodides and bismuth will cause rapid resolution of a gumma in a week. If this therapeutic test is negative, the diagnosis of syphilis must be reconsidered.

Torsion of the spermatic cord leads to a swollen testicle, but the acute painful onset, the age of the patient and the systemic symptoms suggest the proper diagnosis. Torsion of the appendages of the testicle should not confuse the diagnostician.

Contusion of the testis will be accompanied by a history of trauma and great pain, with some systemic reaction, but even mild trauma to a tumor may cause the same symptoms because of hemorrhage into the tumor.

A review of the differential diagnosis suggests the importance of considering all testicular swellings as tumors until they are proved otherwise. Estimations of the gonadotropic hormone in the urine, if positive, will lead to the proper diagnosis but on occasion orchidectomy is carried out for suspected tumor only to find that a benign lesion is present. The surgeon need not apologize, however, since ordinarily such organs are functionally impaired and little has been lost while an accurate diagnosis has been reached.

Orchidectomy for diagnosis. The diagnosis can be determined by histologic examination after castration (Smith, Dresser and Mintz). We can see no advantage in preoperative irradiation of the involved organ as promulgated by the group at Memorial Hospital (Dean, 1935) and others (Randall and Bothe, 1937). Exploration of the mass must be condemned, for such a procedure will only spread the disease. If the spermatic cord is isolated at the external ring, clamped and divided before any manipulation is carried out, no criticism of immediate orchidectomy is tenable, and an accurate diagnosis is made. The loss of a testicle which is tuberculous, luetic or the site of some other form of epididymo-orchitis is negligible should the enlargement prove to be from one of these causes rather than tumor. Furthermore, it is extremely important to learn more about the relation of the structure of the growth to the amount of hormone excreted, to the degree of malignancy, and to the response to irradiation.

Radiosensitivity and radiocurability. In general, the more primitive the tumor, the more active is its endocrine function and the more radiosensitive it proves to be. Unfortunately, radiocurability appears to be in inverse relation to radiosensitivity. The metastases from an undifferentiated adenocarcinoma or a chorionepithelioma may quickly melt away with roentgenotherapy only to recur almost as rapidly despite continuation of irradiation. The monocellular tumors as a rule are less radiosensitive, yet are more radiocurable. A few of these tumors have been controlled with roentgen therapy for ten years and more. This fact suggests the fallacy of quoting the percentage of five-year cures obtained with radiation therapy. At least ten years should elapse before such a patient can be considered cured. This would not apply to the patient treated by castration without irradiation who had never shown metastases. This patient living five years without the development of metastases is cured.

Often during irradiation of metastases the hormonal output in the urine falls rapidly, yet the masses may continue to increase in size. This demonstrates the fact that the trend of endocrine activity is not an index of radiosensitivity or curability. Roentgen rays do not destroy gonadotropic substances but do affect the power of functioning cells to elaborate the hormone.

Treatment. The first step in treatment is orchidectomy. Careful microscopic study of the tumor allows proper diagnosis, and correlation of the microscopic pattern with the degree of endocrine function determined before surgery, suggests much about prognosis. Some of this knowledge is lost if preoperative irradiation of the testis is practiced because the most primitive and malignant cells are radiosensitive.

The number of patients cured by orchidectomy alone is uncertain, most statistics indicating as few as from 15 to 20 per cent. This indicates that metastases have occurred in at least 4 out of 5 patients when first seen. Roentgen therapy is therefore indicated in all cases after orchidectomy has been performed. The rays should be directed at the gland-bearing areas along the aorta and hypogastric vessels. Demonstrable metastases of course must also be treated.

We have given up routine radical resection of the preaortic lymph nodes because this zone is not always primary for metastases. Furthermore, radiation therapy has improved greatly because of advances in technic and the utilization of high voltage machines.

Two weeks after orchidectomy the urine is again tested for gonadotropic substances. If the urine was positive for hormone before orchidectomy and remains so after surgery, metastases are present. If the urine was positive before and becomes negative after surgery and before irradiation, it means that metastases are either absent or too few to excrete the hormone. If the urine, negative before surgery and irradiation, becomes positive afterwards it means that the cells of the metastases have undergone a change in character from those in the primary tumor. This transition, however, rarely occurs. If the urine showed a normal amount of gonadotropic substance before surgery, the amount will undoubtedly remain about the same whether metastases develop or not.

These patients must be seen every 3 to 6 months for many years and examined for abdominal masses and metastases to the lungs and supraclavicular nodes. The urine should be tested periodically for hormone content. The appearance of metastases or an increase in the unitage of hormone in the urine calls for further roentgen therapy.

Prognosis. Testicular neoplasms are very malignant tumors since they metastasize early. The prognosis has been improved somewhat by the routine use of radiation therapy in all patients whether metastases are demonstrable or not. Of 170 patients treated at the Memorial Hospital in New York, Dean was able to report 29 per cent living and well for 5 years or more despite the fact that over half of these survivors had had clinical evidence of metastases or recurrences before treatment was instituted.

The prognosis depends on (1) the pathological type of the primary tumor, (2) the presence or absence of clinical metastases and (3) endocrine function.

Chorionepitheliomata are fatal even in the absence of demonstrable metastases. They are always very actively functioning tumors.

The outlook for patients afflicted by the other types of testicular neoplasms depends upon the degree of differentiation of the malignant cells, and the presence or absence of metastases and urinary gonadotropin.

In general the more primitive tumors, including a few of the adenocarcinomas and the rare, large, clear-cell carcinomas, have a poorer prognosis than do the more differentiated adenocarcinomas and embryonal carcinomas.

The presence of metastases gives a poor prognosis regardless of the reaction to radiation therapy. It is our experience that all of these patients with abnormal amounts of hormone in the urine have a poor prognosis and that most of them die of cancer within a year regardless of roentgenotherapy (Hinman, Johnson and Carr).

The following statements, then, may be made:

1. Patients presenting no demonstrable metastases and without gonadotropic substances in the urine have a good prognosis.

2. Patients with demonstrable metastases but without testicular neoplastic hormone have a poor to fair prognosis depending on their reaction to irradiation.

3. Patients who excrete gonadotropic substances have a poor prognosis whether metastases are demonstrable or not.

DISEASES OF THE EPIDIDYMIS

Introduction. The intimate relation of the epididymis with the testis and spermatic cord renders necessary their consideration together when the epididymis is involved secondarily by disease processes which are primary in the testis and cord.

This chapter is devoted to affections commonly associated with primary involvement of the epididymis, which are considered under three main heads: (1) injuries, (2) inflammations, and (3) tumors. A consideration of gonorrheal epididymitis is to be found in the chapter on gonorrhea and its complications. Cysts of the epididymis and hydrocele are discussed in the section dealing with diseases of the scrotum. Likewise, sterility due to mechanical obstruction of the seminal tract and acute nonspecific epididymitis are discussed elsewhere.

INJURIES OF THE EPIDIDYMIS

The epididymis is frequently injured in contusions and wounds of the scrotum and testicle because of their intimate relation to each other, so that a separate description is unnecessary and the reader is referred to those sections treating of injuries of the scrotum and testicle, and particularly to the condition termed "traumatic epididymo-orchitis." The importance of cremasteric spasm as a cause of injury should be kept in mind, and also the frequency of atrophy of the testicle consequent upon seemingly insignificant injuries. In injuries involving the epididymes the likelihood of sterility should be remembered.

TUBERCULOSIS OF THE EPIDIDYMIS

Etiology. Tuberculosis of the genito-urinary tract has long been recognized in its ultimate stages as a combined-system disease, affecting both the genital and the urinary tracts, but in its initial stages it is limited to one or the other — most frequently to the urinary tract. All clinical, experimental and pathological evidence concurs in the doctrine that, in the urinary tract, the primary focus occurs in the kidney.

As regards the genital tract, the general clinical view is held, and medical students have long been taught, that tuberculosis has its primary focus in the epididymis in the majority of cases; from that focus it occasionally involves the testicle, and sooner or later spreads to the prostate and seminal vesicles and to the opposite side.

In the last analysis, careful scrutiny of accumulated clinical, experimental and pathological evidence rather upsets this time-honored tenet, and forces us to be very chary of orthodox statements as to the pathogenesis of genital tuberculosis.

A voluminous literature has arisen upon the subject, the more important contributions of which are listed in the bibliography. Worthy of emphasis are the monographic contribution of George Walker, which is of immense value from the experimental point of view and which contains a very complete bibliography up to 1911; the excellent article of K. M. Walker whose clinical, experimental and pathological deductions led him to conclusions quite at variance with George Walker's; the studious contributions of Barney, who has made a life-long clinical study of the problem, and who in his last analysis (1927) cited the most important literature since 1911; and finally the clear-cut, detailed articles of Young, whose clinical studies, opposed to Barney's, are particularly important from the standpoint of treatment.

In a consideration of genital tuberculosis it is important to understand clearly that tuberculosis of this region is the subject of dispute as regards both pathogenesis and treatment — a dispute which only the lapse of time and a great deal of research will settle. It is indeed stimulating to examine the mass of evidence supporting opposite contentions, and to realize the extreme intricacy of the problems involved. Evidence is adduced which at first seems incontrovertible, only to be followed by that which is contradictory, but apparently equally well supported.

In regard to pathogenesis, opinion is divided: one group believes that the primary focus of tuberculosis is in the epididymis, while the other argues just as strongly that it is in the prostate and seminal vesicles. To give a proper background upon which to build an opinion about genital tuberculosis, the chief evidence put forward by the two opposing groups will be cited briefly.

K. M. Walker summarized the important evidence in favor of a primary focus in the prostate and seminal vesicles, rather than the epididymis, as follows:

" *Clinical.* 1. It is extremely rare to find tubercle of the epididymis without discovering some indication of disease of the prostate or vesicles.

" 2. Prostatic tubercle is frequently found without any lesion of the testicle (epididymis).

" 3. The appearance of a tuberculous epididymitis is often preceded by symptoms of prostatitis or vesiculitis — the so-called prodromata of tuberculous epididymitis.

" 4. The earliest signs of tuberculous disease are found at the lower pole of the epididymis. This is the first position which opposes the line of march of the invading organism.

" 5. Tuberculous disease of the testicle is analogous to acute infections which are known to have been produced by extension from the urethra. The ordinary type of tuberculous epididymitis has an analogy to the hematogenous orchitis of mumps.

" *Pathological evidence.* 1. Lesions of the testicle (epididymis) without disease of the prostate are rare, whereas tuberculous lesions of the prostate are not infrequently found unaccompanied by disease of the testicle.

" 2. When tubercle of the testicle is found in association with tubercle of the prostate, the lesions in the prostate generally have the appearance of being older than the lesions in the epididymis.

" 3. Tuberculous nodules in the lower pole of the epididymis usually appear older than those in the upper pole. They are the first to soften and break down.

" *Experimental evidence.* 1. Microörganisms and inanimate granules are rapidly absorbed from the urethra and carried to the testicle (epididymis).

" 2. A tuberculous epididymitis may be experimentally obtained by inoculating the urethra after having damaged one of the testicles."

The general opinion of clinicians that the disease is primary in the epididymis has been reached because the epididymal involvement is so obvious, while the lesions in the prostate and vesicles are hidden and may remain undiscovered even on rectal palpation. It is furthermore generally accepted that the tubercle bacillus reaches the epididymis by way of the blood-stream, as a rule, from some other focus in the body. If that is so, why does it not attack the testicle as do other hematogenous infections — (pyemia, mumps, variola, scarlet fever, typhoid, et cetera)? We know that gonorrheal epididymitis and other infections extending to the epididymis from the prostate and seminal vesicles arrive there either by way of the lumen of the vas or through the lymphatics of the vas, and that they affect only the epididymis and primarily its lower pole (globus minor). We know also that tuberculosis, as found clinically, involves only the epididymis and at first only its lower pole. To complete the syllogism, therefore, the tuberculous process must be primary in the prostate and seminal vesicles. George Walker, in a series of 28 rabbits in which injections of tubercle bacilli were made into the aorta, found that 5 showed involvement of the testes, and in 2 of these the epididymes were free from infection. K. M. Walker believed the extension from the prostate to the testicle and epididymis to be by way of the lymphatics rather than the lumen of the vas, because, in patients examined, the prostatic and epididymal ends of the vas were frequently involved while its intervening portion was free from disease; moreover, the lumen of the vas appeared healthy throughout but at its extremities the vas was surrounded by a shell of tuberculous tissue. As the process progressed, the lumen became involved at its epididymal extremity.

If we grant that the primary focus in the genital tract is the prostate or seminal vesicles, how does tuberculosis reach these structures?

Four possibilities (K. M. Walker) present themselves:

1. Infection by way of the blood-stream.
2. Extension of the disease by continuity of structure.
3. Direct infection per urethram.
4. Infection through the agency of the urine.

It seems that all four modes of infection are encountered. The least certain is direct infection per urethram, but the high frequency of conjugal genital tuberculosis is suggestive, though the relation remains uncertain. Although susceptible to experimental production, no proved clinical cases are reported (George Walker). Infection by means of the urine is particularly likely to occur, and secondary infection of the prostate and seminal vesicles from a primary focus in the kidney may occur without infection of the bladder; infection of the kidney can take place, likewise, from the prostate and vesicles. Infection by the blood-stream is undoubtedly the most frequent route.

Simmonds concluded from a careful study of 200 necropsies of patients who died from genital or urogenital tuberculosis, that: (1) the primary focus in the genital tract proceeds from the prostate in one-half of the cases, while in one-quarter of the cases it arises in the seminal vesicle or in the epididymis. (2) From these centers the process can spread in the direction of the testicle or away from it.

Young, from an exhaustive review of the literature and a large surgical experience, came to the conclusion that the majority of cases of genital tuberculosis are primary in the seminal vesicles, and proposed the term " tuberculosis of the seminal tract " as appropriate.

Now let us turn for a moment to the evidence adduced to prove the primary focus to be in the epididymis.

George Walker stated, from a large mass of experimental data, that: " Tuberculosis may descend from the vesicles and prostate to the epididymis, but ascension from the epididymis to these organs is much more common and is practically the only condition of surgical importance. Primary tuberculosis of the prostate or vesicles is so rare that it may be discarded." In his experiments he used a fairly virulent strain of bovine organisms with which to inoculate his animals. Eastwood and Griffith drew attention to the fact that all cases of genital tuberculosis in human beings are apparently caused by the human type of organism. Consequently, no matter how carefully controlled, experimental work is more or less discredited by the altered conditions and the fallacy of drawing too close analogies between the reactions in animals of different species and those in the different organs of the same animal, as well as the differences under which the organisms are maintained and the disease contracted. It would be fallacious to say that, because the organisms causing lobar pneumonia affect chiefly the lower lobes, the tubercle bacillus must therefore do likewise; nor can we accept with any certainty the usual reasons offered as to why the tubercle bacillus affects the epididymis rather than the testicle.

Autopsy records show that primary tuberculosis of the prostate and the seminal vesicles (independently or together with the prostate), as well as primary tuberculosis of the epididymis, does occur, nor will the most ardent exponents of either group deny it (Scott). At the same time, it is so seldom that one lesion is found without the other that it is extremely difficult or impossible to judge in which organ the process is primary. Erroneous conclusions are easily reached, because, as George Walker showed, the lesion which appears to be the more advanced of the two is not necessarily the primary, or older one.

Barney, on the basis of 154 personal cases carefully followed, and from a thorough knowledge of the literature, concluded that the primary focus arises in the epididymis in the great majority of cases.

At the meeting of the International Society of Urologists in Brussels in 1927 (for consideration of the subject " The Treatment of Genital Tuberculosis in the Male ") Barney and K. M. Walker, representing America and Great Britain respectively, still held their divergent views. The Italian delegates (Gamberini of Bologna and Marogna of Sassari) sided with Walker in the expression of his views, as follows: " It must not be forgotten that every one of these organs (prostate, seminal vesicles and epididymis) may be involved in an equal degree, though the anatomopathologic statistics give the greatest importance to the prostate and seminal vesicles."[1]

Pathology. Genital tuberculosis is found in from 2 to 5 per cent of all adult tuberculous subjects (Barney). Whether more cases are primary in the prostate and seminal vesicles, or in the epididymis, we are not prepared to say at present. Clinically, however, when the patient first appears for treatment, one or both of the epididymes are involved, and on rectal palpation changes in the prostate or vesicles may or may not be found. It is certain, however, that if the epididymis is involved, the prostate or seminal vesicles are likewise involved in the majority of cases (for statistics, see Barney); in fact, for practical purposes, it may be taken for granted that they are always involved, either unilaterally or bilaterally. (See Table IV.)

Statistics vary, but nearly all cases are secondary to a latent, healed or active focus somewhere else in the body. This focus is

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[1] Transactions, Troisième Congrès de la Société internationale d'Urologie, Bruxelles, August, 1927, p. 66.

TABLE IV. DISTRIBUTION OF TUBERCULOSIS IN GENITAL ORGANS

Tb. of Genital or Uro-genital Tract	*Epididymis*		*Prostate*	*Seminal Vesicles*		*Testis*	*Epi-didymis only*	*Prostate only*	*Seminal Vesicles only*	*Kidney*		*Bladder*	*Other Struc-tures*	*Author*
	Unilat.	*Bilat.*		*Unilat.*	*Bilat.*					*Unilat.*	*Bilat.*			
.....	20	15	25	14	11	19	10	2	0	11	5	16	.....	Cunningham
.....	86		59	41		.....	.....	.....	.....	9	5	16	75	Cunningham
35	.....	.....	26	29		.....	.....	.....	.....	.....	.....	.....	.....	Simmonds
37	.....	.....	18	17		.....	.....	.....	.....	.....	.....	.....	(lung) 81 %	Oppenheim
15	.....	.....	14	11		.....	.....	.....	.....	.....	.....	.....	.....	Krzywicki
70	.....	.....	44	36		.....	.....	.....	.....	.....	.....	.....	.....	Collinet
547	.....	.....	.....	.....	.....	.....	.....	9	2	.....	.....	.....	.....	Saxtorph
.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	Crandon
57	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	Teutschlaender
183	.....	.....	.....	.....	.....	.....	.....	10		.....	.....	.....	.....	Guisy
44	44		.....	.....	.....	.....	0	0	0	.....	.....	.....	(lung) 80 %	Socin and Burckhardt
222	.....	.....	77 %	83 %		.....	.....	14	.....	.....	.....	.....	.....	Scott
154	.....	.....	.....	.....	.....	.....	.....	.....	.....	18		.....	.....	Barney
100	.....	.....	.....	.....	.....	.....	.....	.....	.....	20		.....	.....	Keyes
1675	.....	.....	69	7 %	.....	57.6 %	.....	.....	28.5 %	.....	.....	.....	.....	Barney
815	.....	.....	68.5 %	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Hesse
.....	.....	.....	73 %	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Burckhardt
642	.....	.....	.....	.....	.....	.....	.....	21.6 %	.....	.....	.....	.....	.....	Barney
127	.....	.....	.....	.....	.....	.....	.....	11	.....	.....	.....	.....	.....	Sawamura
.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....	.....	.....	.....	Young
127	←	—	—58—	—	—	→	2	56	11	.....	.....	.....	.....	Guyon
40	.....	.....	.....	.....	.....	.....	10	20	10	.....	.....	.....	.....	Simmonds
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(lung) 80 %	Kocher
154	154		.....	.....	.....	66	.....	.....	.....	.....	.....	.....	.....	Barney
72	72		82. %	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Halle & Motz

most often in the lungs. In cases in which both genital and urinary tracts are involved Barney thinks it probable that the genital lesion is usually the primary one.

A characteristic of urogenital tuberculosis is the fact that the disease is progressive, and does not heal as it does in the lung. Its activity may be periodic with latent intervals, but in all cases the process continues until the organ is ultimately destroyed. Eventually the patient will die unless surgical intervention enables him to recover.

Whether in the prostate and seminal vesicles, or in the epididymis, tuberculosis, which as a rule is hematogenous in origin, begins with the formation of tubercles beneath the tubular epithelium. It is characterized by chronicity, a tendency to periodicity, with early or late formation of sinuses and the gradual replacement of normal structures by dense connective tissue.

The disease spreads by direct extension and reaches other organs by means of lymphatic extension. In the epididymis, the globus minor is first involved, with subsequent spread to the rest of the epididymis, the tubercles coalescing and ulcerating through the tubular epithelium and filling the epididymis with nodular caseous areas. In those rare instances in which tuberculosis of hematogenous origin is primary in the epididymis, the globus major is usually the first portion involved. The proximal portion of the lumen of the vas is similarly affected. By lymphatic extension the corpus Highmori of the testicle often becomes included in the process. It is rare indeed that the testis is the primary seat of the disease (Mark). When tuberculous epididymitis is encountered clinically, the physician may be sure that, in the majority of cases, the disease is at least as far advanced in the prostate and vesicles as it is in the epididymis, if not farther. This is true whether extension to the prostate and vesicles occurred at an early stage through the lymphatics about the vas deferens, or whether there was an early extension to the epididymis (globus minor) from the prostate and vesicles by antiperistalsis or reflux in the vas. Let us assume that 100 cases of tuberculous epididymitis are seen clinically. In all of the 100 cases the globus minor will be involved, and that lesion will be most extensive; in 90 per cent of the cases the globus minor and mid-portion of the epididymis will be involved; in 66 per cent, the whole epididymis; in 41 per cent, the entire epididymis and corpus Highmori; and in 16 per cent the entire epididymis, corpus Highmori and body of the testis will be affected. Or conversely, of 100 cases, in 84 there will be no involvement of the body of the testis; in 59, no involvement of the testis and corpus Highmori; in 34, no involvement of testis, corpus Highmori, globus major and mid-portion of epididymis; all will show involvement of the globus minor. These figures are only of relative value and other series showing different percentages have been reported; thus Barney found that in 60 per cent of cases the testicle was involved, while Mark found the corpus Highmori to be affected in only 41 per cent and the body of the testis in 16 per cent.

When tuberculosis infects one epididymis, the opposite epididymis will become involved sooner or later, usually within a year, either by the same route, ascending by way of the vas deferens from the prostate or seminal vesicles, or by way of the bloodstream. Frequently the disease is apparently bilateral at the onset. Urogenital tuberculosis is rare in children, and its greatest frequency is between the ages of 20 and 50. Barney, who made the most complete study of the condition in children, stated that, in tuberculous epididymitis in children, involvement of the prostate or seminal vesicles is very rare, and that prostatic and vesicular tuberculosis is most frequent during the time of greatest activity in these organs, i.e., from the twentieth to the fortieth year. In the majority of cases, urogenital tuberculosis can be traced to a focus somewhere else in the body. This focus, as Barney showed in his 154 cases of tuberculous epididymitis, is most frequently in the lung (Table IV), infections of the kidney and bone being next in frequency. Other foci that should always be searched for, though they are less common, are those in joints, larynx, glands, meninges, middle ear, peritoneum and ischiorectal fossa. It is only very rarely that a primary focus outside of the urogenital tract cannot be found, either clinically or at autopsy.

Tuberculosis of the testicle manifests itself first in the corpus Highmori. In the experiments of George Walker, in which tubercle bacilli were injected into the aorta, the animals which developed primary tuberculosis of the testicle showed the principal lesions at the periphery of the gland. The tunica albuginea was studded with tubercles while the central part of the testicle showed little involvement. In these cases, tubercles were found immediately about the capillaries in the intracanalicular connective tissue or just under the epithelium.

In the lymphogenous type of tuberculosis which characterizes clinical cases, authorities disagree as to whether the tubular system or connective tissue is first affected. Barney's studies showed that the process in general is intertubular, and that surprisingly active spermatogenesis proceeds even in advanced destruction of the gland. In spite of this active spermatogenesis, however, these patients usually show a very early azoöspermia, showing that both vasa must be obstructed very early, and adding to the evidence supporting extensive involvement of the prostate or vesicles in cases of tuberculosis of the epididymis. Clinically, tuberculosis of the testicle often gives no evidence of its presence because of its central location, and exploratory orchidotomy may be indicated in case of doubt. In a recent personal case both testicles were negative externally except for adhesions of the tunica vaginalis, yet orchidotomy showed both of them to be seeded with caseous nodules from 3 to 4 mm. in diameter. The testicle may show multiple foci throughout, or in small areas, or a single large focus. By extension and coalition the entire testicle becomes a caseous mass. On the other hand, the disease process in the epididymis often assumes extensive proportions, and the testicle will be found as a small compressed organ quite free from involvement. Eventually the surrounding tissues and skin become adherent and the process ulcerates through, forming a chronic discharging sinus. If the sinus connects with the epididymis, it is most likely to be situated on the posterior aspect of the scrotum; if with the testicle, it probably will be found on the anterior surface.

As in other tuberculous lesions, those of the urogenital organs undergo fibrosis, caseation, calcification or suppuration. The first is to be hoped for, the last particularly dreaded.

Diagnosis. Although at times easy, the differential diagnosis is often so difficult as to tax all our diagnostic resources. The first step is a careful history. Inquiry for evidence of tuberculosis in the family history, and for possible infection in childhood is indicated. Most patients seek treatment within six months of the supposed onset of the disease (Barney), though the onset is often insidious. Most of these patients will have lost weight. Pain and tenderness are generally either mild and intermittent or absent, but are to be expected at some stage in the disease. Symptoms of disease in the bladder and abnormal urine will be found in a considerable number. Occasionally, the first and only symptoms are referable to the bladder, such as frequency and burning on urination, and sometimes pyuria or hematuria; or a bloody discharge at the end of urination, or on ejaculation, is noted. Whether these initial symptoms are caused by secretions from the epididymis or by involvement of the prostate or vesicles is not clear. Sexual desire and potency are rarely impaired, even though double orchidectomy has been done, but azoöspermia occurs at an early stage. A history of exacerbations and remissions is common, and that of hydrocele with frequent tappings is not infrequent. In others, a scrotal abscess has been lanced with resultant formation of a sinus. Barney found bilateral involvement in 29.3 per cent of his patients. In cases in which the disease was unilateral it became bilateral in 26.5 per cent of patients within six months, and in 38.7 per cent within twelve months. In 16.3 per cent of all patients the disease was apparently bilateral from the beginning. Involvement of the opposite side, however, has been known to be delayed as long as eight years. In Barney's series, 80 per cent of the patients lost weight, but others had gained weight and appeared in excellent health. Only 10 of his patients had fever before operation. Pain, local or radiating to the groin or lumbar region, was noted in 60 per cent but there was no pain referable to the prostate or vesicles. Symptoms in the bladder occurred with tuberculosis involving the bladder from the prostate or kidneys. Scrotal sinuses were present in 77.3 per cent of patients. Fifty per cent of these occurred within six months of the onset of the disease, and 71 per cent within the first year. With so frequent and early an infection of the prostate and seminal vesicles the neck of the bladder early becomes irritated. Thirty-five per cent of the patients in Barney's series had urinary symptoms such as frequency, dysuria and urgency, and in 49 per cent the urinary symptoms came on during the first six months of the disease.

All the preceding factors should be elicited in the history of a case, following which a thorough physical examination is indicated. A careful search should be made for a primary focus outside the urogenital tract, as the character of the primary focus has an important bearing on treatment. All patients with urogenital tuberculosis should have a most careful examination of the lungs, not only physically but roentgenographically as well.

Only after a careful history has been obtained and a thorough general physical examination performed should attention be directed to the urogenital tract; then a routine urological investigation, in whole or in part, depending upon the particular case, should be done along lines laid down in earlier chapters. A careful examination of the external genitalia should first be made, and the character of the scrotum, testicles, epididymes and vasa noted. If hydrocele is present, palpation will be facilitated by withdrawal of some of the fluid; this procedure also permits an acid-fast stain, and tubercle bacilli sometimes can be found in this fluid. Too often an examination of the vasa is entirely overlooked. A rectal examination should next be made and the prostate and vesicles carefully palpated for evidence of pathological change. Hard, nodular indurations and adhesions are characteristic of tuberculous processes, but the evidence may be so slight, even in advanced cases, as to be overlooked by palpation. (See Figures 25 and 26.) Sufficient secretion for examination should be expressed gently, in doubtful cases, and examined for pus, and an acid-fast stain should be made, although Cunningham stated that in only 15 per cent of cases will the tubercle bacilli be demonstrated by the latter procedure.

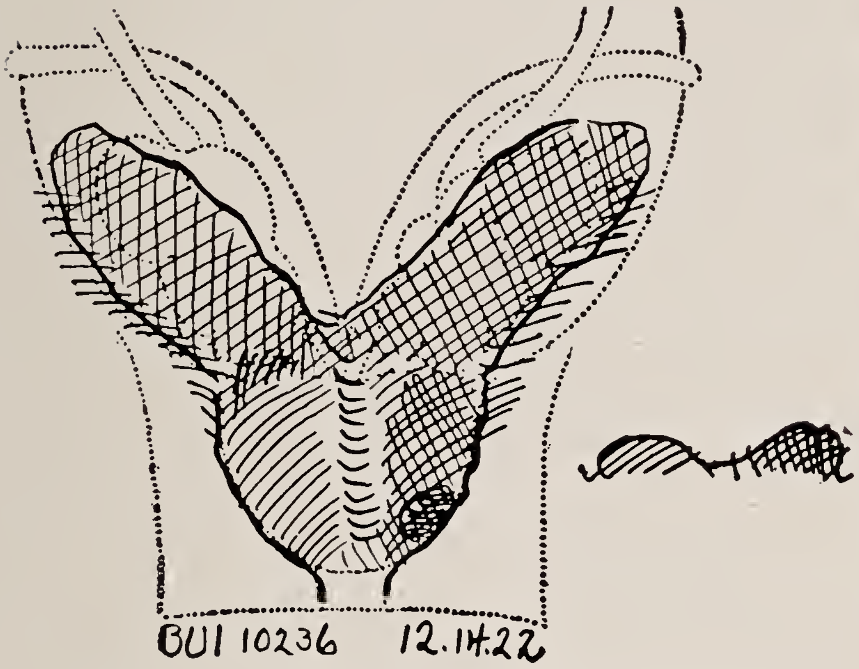

Fig. 25. Drawing of palpatory findings on rectal examination of a case of bilateral genital tuberculosis. (Young's Urology, p. 310.) The nodule in the lower right side of the prostate is a characteristic finding. Both epididymes were involved.

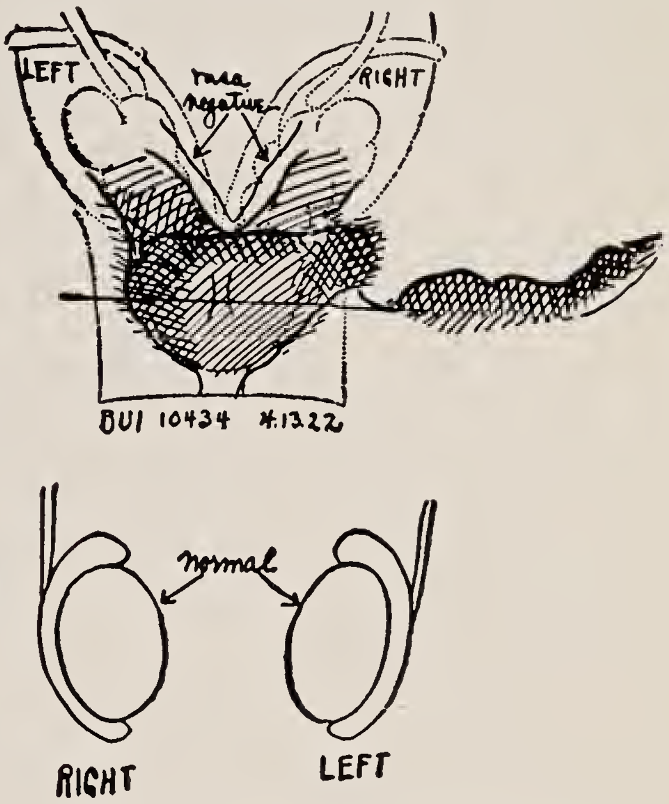

Fig. 26. Rectal and scrotal findings in a case of tuberculosis of the prostate and left seminal vesicle. (Young's Urology, p. 329.) The case came to autopsy, which showed that there was no involvement of either epididymis.

A careful examination of the urine is next indicated and the presence of pus, blood, bacteria, and albumin in particular should be noted. It is absolutely essential to determine the state of the kidneys, because the focus may be primary there, affecting the epididymis secondarily, or the kidneys may be involved secondarily from the epididymis. Barney, in 154 cases of tuberculous epididymitis, found renal tuberculosis in 18 patients, the genital lesion preceding the renal in 11, and vice versa in 7.

If the urine is negative, further urological investigation is unnecessary, but if it is abnormal in any respect, the possibility of renal infection must be ruled out, first by plain x-ray films of the kidneys, ureters and bladder and a total phenolsulphonephthalein test, followed by cystoscopic investigation with differential functional and urinary studies. These diagnostic steps are of great moment in determining prognosis and treatment.

The findings in tuberculosis confined to the genital tract must be limited in large measure to presumptive evidence, yet the diagnosis is almost certain in a patient who has a large, hard, nodular epididymis with a similar condition in the prostate or vesicles, and abnormal urine, together with a scrotal fistula, or the healed scar of one, and a history of chronicity and gradual onset. The findings are not so evident, however, in many cases and the disease must be differentiated from chronic nontuberculous inflammation, syphilis and tumor.

Stevens, at Bellevue Hospital (N. Y.), reviewed an extensive series of cases of chronic epididymitis in an attempt to evaluate certain features which have been considered of diagnostic value in the past, and to determine additional dependable points of differentiation between tuberculous and nontuberculous epididymitis. This seemed to him especially important in those cases which did not follow operation, instrumentation, or gonorrhea and in which there was no history of gonorrhea or other gross urinary infection. The physician is frequently confronted with such cases, in which it is essential to rule out tuberculosis. Stevens stated that the difficulties of diagnosis were emphasized by the fact that in 20 of 35 cases in which operation was done following a preoperative diagnosis of tuberculosis, pathological examination proved the disease to be simple chronic inflammation. In the group of 74 cases of tuberculosis, however, the wrong diagnosis was made but once and that was in a case of gumma with the formation of a sinus.

The chief differential points brought out by this interesting review were:

1. Bilateral epididymitis slightly favors a diagnosis of tuberculosis.

2. A history of previous epididymectomy points almost without exception to a diagnosis of tuberculosis.

3. The occurrence of fistula is greatly in favor of tuberculosis. A persistent fistula is very unusual in cases of simple inflammation.

4. The age incidence is of no differential value.

5. A history of trauma is of no importance, because 10 per cent of both groups dated the onset of the disease from trauma.

6. The history of previous gonorrhea and acute epididymitis was of no diagnostic value. Contrary to what might be expected, more tuberculous than nontuberculous patients gave a history of previous involvement of the epididymis.

7. In over 90 per cent of patients with evidence of tuberculosis elsewhere the diseased epididymis was tuberculous.

8. Nearly all patients with tuberculous epididymitis (55 of 62) showed pathological alterations of the prostate and seminal vesicles on rectal palpation. Over half the nontuberculous patients likewise showed changes. Although at times difficult to differentiate, tuberculous patients evidence on palpation an extreme nodular induration which is lacking in nontuberculous patients. The longer the duration of the tuberculous lesion the more marked are the changes in the prostate and vesicles, while the reverse holds true in nontuberculous infections of the epididymis.

9. The duration of the disease offers no other features of differential value.

10. An enlarged, thickened, or nodular vas deferens is not of diagnostic value, as such a finding frequently occurred in both groups. Involvement of the lower end of the vas (near the testicle) occurred with equal frequency in both groups.

11. Syphilis, if it involves the epididymis alone (a rare condition), may be differentiated by negative rectal findings, and by its preference for the globus major. The history, physical examination and Wassermann test are indicated in case of doubt. It must be borne in mind that syphilis and tuberculosis frequently coexist.

Tumors are extremely rare in the epididymis but, when present, may complicate the diagnosis (see Tumors of the Epididymis). Cysts (spermatoceles) are more common but rarely are confused with tuberculosis. Testicular tumors sometimes offer difficulties in differentiation, as shown in the pages on testicular tumors.

Treatment. The high morbidity of genital tuberculosis — even in patients who have had the benefit of accepted methods of treatment — is not appreciated generally. As has been shown, the disease is progressive, and fairly rapid in its evolution. The ultimate mortality varies, in the reports of different authors, from 27 to 60 per cent (Young). Barney traced 113 patients, upon whom epididymectomy had been performed, from one to twenty-five years and found that over 27 per cent were dead of some form of tuberculosis; 50 per cent of these died within one year after operation and 85 per cent within six years. He concluded that the prognosis is very unfavorable.

Without operation death is almost certain, while with operation, the prospects have not been improved to the extent that was hoped. Barney showed that ten years must elapse before the danger of death from tuberculosis is past.

As to methods of treatment, opinion is divided between two factions, one espoused by Barney, favoring the conservative operation of epididymovasectomy, the other by Young, who is a strong advocate of the radical operation, consisting of the removal of the whole genital tract on one or both sides (epididymis, vas, seminal vesicle and prostate).

Of course, all patients do not fall in the same category as regards treatment, and before electing the type of treatment it is essential to have, besides a complete knowledge of the genitourinary system, the evidence furnished by a thorough physical examination. The patient's resistance and the extent and activity of the disease must all be taken into consideration in determining treatment. In the presence of fever, for example, operation should not be undertaken but, by rest in bed and general hygienic measures, the temperature should be brought to normal. Surgery is only a small part of treatment. In patients suffering from active tuberculosis elsewhere in the body, preliminary hygienic treatment relative to fresh air, sunlight, food, work and sleep is necessary to the best interests of the patient, as has been emphasized by Martin. Many observers consider injections of tuberculin to be of great value, both before and after surgical procedures. Augé and Alinat reported five cases of tuberculosis cured by the ultra-violet rays. Wildbolz reported that heliotherapy had no beneficial effect. Freund found roentgenotherapy of definite value in a series of 15 cases. In his opinion, the effect obtained was not the destruction of the organism but the stimulation of granulation tissue, whereby tuberculosis limited to the epididymis and testicle could be actually cured, and fistulæ healed. In advanced cases roentgenotherapy will check the spread of the disease. Freund advised only moderately hard rays in small doses, and stated that in some cases partial resection might well precede irradiation.

In tuberculosis of the kidney associated with tuberculous epididymitis, the affected kidney should be removed, if the disease is unilateral, before removal of the epididymis. If bilateral, it is probable that little will be gained through surgery, and palliative measures are indicated (Martin).

Marinesco outlined the history of epididymectomy in a most interesting manner. We shall not discuss its technic but only the indications for it. The advantage of the radical operation of Young is seen in the complete elimination of the disease from the genital tract since, as has been shown, tuberculosis of the prostate and vesicles rarely exists without involvement of the epididymis, and vice versa. The radical operation would therefore be unhesitatingly advised by everyone for all cases of tuberculous epididymitis were it not for the gravity of the procedure, and the further lowering of the patient's resistance by a long and tedious operation. The conservative operation often results in subsidence of the disease in the prostate and vesicles, with clinical cure, but as Barney shows, activity frequently continues unabated, or in patients apparently cured by unilateral epididymectomy, involvement of the remaining epididymis occurs subsequently in an uncomfortable proportion of cases, and the ultimate prognosis is bad. Young felt that the results in 24 cases justified his continuation of the radical operation. In our practice, the results of radical operation on 18 patients are most favorable. Seventeen of the 18 patients are living; one died of miliary tuberculosis. Quinby reported seven radical operations with very favorable immediate results. Dillon emphasized the deplorable results of the conservative operation and collected 59 cases of radical operation performed in this country, including five of his own. Although no conclusions were drawn, the extent of the process in genital tuberculosis is well shown. K. M. Walker summarized his own views as follows: "Of the surgical procedures I consider epididymectomy to be the operation of widest application. Although the more radical operation of total extirpation of the seminal tract is based on a correct understanding of the pathology of the disease, I still regard it as a measure only to be adopted in special cases, namely those in which regression of the central lesions has not followed epididymectomy, and also in the treatment of those patients with marked involvement of the prostate and vesicles, whose mode of life handicaps them from the outset in their fight against the tuberculous invasion." The success of the radical operation depends, as does perineal prostatectomy, upon thorough anatomical knowledge combined with the dexterity and rapidity that come with experience. Success for the patient depends upon whether the surgeon makes the removal a three-hour struggle or an easy one-hour operation. Perineal prostatectomy is condemned by the unskillful, and espoused by the skillful perineal surgeon, and probably such will be the fate of the radical operation for genital tuberculosis. In the hands of the general surgeon the patient will undoubtedly be better off with the conservative operation. The frequency with which the apparently healthy opposite epididymis becomes diseased subsequent to the first epididymectomy has caused Wallner and others to advise transecting or resecting a portion of the vas to prevent extension of the process to the remaining epididymis, and Barney ('11) advised bilateral epididymectomy in almost all cases, even though one epididymis seemed healthy. If the testicle shows the slightest evidence of infection, it should be surgically explored and grossly diseased areas should be removed. Castration should be done only in cases of marked destruction of the testicle. In view of the difficulties of diagnosis, and our own two notable mistakes mentioned above, where radical operation is contemplated, epididymectomy should be the first step so that pathological confirmation may be had before undertaking radical resection of the vesicles.

In France, although opinions differ as to the primary focus of the disease, radical surgical procedures of various sorts have been more generally used. Ertzbischoff stated that the prostate is the most frequent site of genital tuberculosis. Legueu was of the opinion that genital tuberculosis involves the prostate, seminal vesicles, vas deferens and testicle, and that, while it may be primary in any one of these structures, extension is so rapid that, usually, patients must be considered as having tuberculosis of the whole seminal tract when first seen. Sebileau and Descomps, Legueu, Pauchet, Ertzbischoff, and others have presented valuable historical accounts of the development of various surgical procedures in the treatment of genital tuberculosis. Pauchet, in 1909, described a radical operation similar to Young's and radical procedures are commonly used by many of the French urologists, at least in selected cases.

SYPHILIS OF THE EPIDIDYMIS

Etiology. In the chapter on diseases of the testicle the fact was emphasized that syphilis always involves the testicle (as might be expected in hematogenous affections), while tuberculosis is characterized by its affinity for the epididymis. Diagnosis is complicated by the fact that this condition may occasionally be reversed. The rarity with which syphilis affects the epididymis without involving the testicle is attested by the paucity of literature upon the subject. The actual frequency of testicular involvement in the form of chronic syphilitic interstitial orchitis, in spite of its seeming clinical rarity because of the lack of signs or symptoms, has been emphasized. Almost the only available articles of late years are those of Herman and Klauder, Lisser and Hinman, Wright, Michelson, Klauder, McLachlan, and the excellent contribution by Lloyd Thompson on syphilis of the genital organs of the male. In many instances the *Treponema pallidum* involves the epididymis by direct extension from the testicle, so that it is difficult to distinguish them in the mass and impossible to say in which of the two organs the disease is primary. In such cases, however, probability strongly favors primary infection of the testicle. In surgical diagnosis it is important to bear in mind the fact that syphilis may occur in the epididymis without involvement of the testicle.

Pathological changes. As in syphilis of the testicle, syphilis of the epididymis occurs in three forms:

(1) Acute interstitial epididymitis
(2) Chronic interstitial epididymitis
(3) Gumma of the epididymis

The acute interstitial variety may occur as early as the second month of the disease or as late as the fifth year. The swelling, usually not very great, nearly always begins in the globus major, though the whole epididymis may be involved, and is generally accompanied by effusion in the tunica vaginalis (hydrocele). The condition is most commonly unilateral, but both sides may be involved.

The chronic variety either comes on insidiously, as does tuberculosis, or follows the acute condition. It rarely occurs before the third year of the disease. The swelling primarily affects the globus major and is diffuse, unlike the nodular condition of tuberculosis.

Gummata are late manifestations of syphilis. These lesions are usually multiple but rarely bilateral, although Klauder cited such a condition in a paretic. In contradistinction to interstitial orchitis, they consist of one or more hard nodular masses in the epididymis. Like tuberculosis, gummata may break down and form scrotal fistulæ.

Diagnosis. Acute syphilitic epididymitis, like gonorrheal epididymitis, begins rather suddenly, is accompanied by pain and tenderness, and might easily be confused with gonorrheal disease except that it involves primarily the globus major, while gonorrheal epididymitis first attacks the globus minor. Furthermore, in syphilis, the surface of the epididymis is smooth and elastic and is, therefore, more easily distinguished from the testicle than is the case in fulminating gonorrheal epididymitis. The process generally subsides in a few days, leaving indurated areas, and a chronic course supervenes. In the chronic condition, whether gummatous or interstitial, difficulty will be encountered in distinguishing it from tuberculosis, simple chronic inflammation and tumor, but, in this instance also, the primary involvement of the globus major in syphilis may aid in differentiation in some cases. Of course, the history is of great importance, as well as the recognition of an acute urethritis or the stigmata of syphilis. Rectal palpation of the prostate and vesicles gives valuable information. In syphilis pathological alterations are not to be expected, but in tuberculosis the findings are often characteristic. Tumors, other than cysts, of the epididymis are rare, but malignant tumors primary in the epididymis may be extremely difficult to differentiate (see Tumors of the Epididymis). Drainage of the tunica vaginalis, which is so general an accompaniment of the treatment of diseases of the testicle and epididymis, often permits more accurate deductions from palpation.

Treatment. Antiluetic treatment is indicated.

Simple Chronic Inflammation of the Epididymis

Etiology. In the discussion of the differential diagnosis of the varied lesions of the testicle and epididymis, reference has been made to simple chronic inflammation of the epididymis (see Diagnosis of Tuberculous Epididymitis) occurring either insidiously or following upon an acute infection, in which the infectious agent was neither tuberculous, syphilitic nor gonorrheal, and the etiological factor often obscure (Stevens). Often chronic inflammation of the epididymis persists indefinitely following acute gonorrheal epididymitis, but in other cases the disease occurs in those who have not had gonorrhea and sometimes give no history of an acute epididymitis in the past. The infecting organisms cultured from these patients are usually, as Koll has shown, the colon bacillus, Staphylococcus, or occasionally Streptococcus, their primary focus being in the seminal vesicles, prostate, sinuses or some other place in the body.

Pathological changes. Chronic inflammatory changes of this type are characterized by swelling and induration of the epididymis caused by leukocytic and lymphocytic infiltration and fibroplastic proliferation, producing a clinical picture very similar, in many respects, to syphilis or tuberculosis.

Diagnosis. The condition must be differentiated from syphilis, tuberculosis, and tumor. Syphilis is characterized by its preference for the globus major, and can be eliminated by serologic and therapeutic tests. A careful history is necessary to eliminate possible gonorrhea with gonorrheal epididymitis, and tuberculosis. If bilateral, the diagnosis of tuberculosis is favored. If scrotal fistulæ are present, it is unlikely that the process is simple inflammation. At times, as Stevens has shown, differentiation can be made only at operation.

Treatment. The condition is clinically important only as a result of the possible discomfort to the patient with which it may be attended, and possible recurrent acute exacerbations. In some instances, just as chronic prostatitis and seminal vesiculitis are very definite factors in maintaining a chronic inflammation of the epididymis, so the reverse condition may be true, and chronic epididymitis will form a basis for a chronic prostatitis and vesiculitis. Under such conditions an epididymectomy may be indicated.

TUMORS OF THE EPIDIDYMIS

Introduction. Primary tumors of the epididymis are rare and until recently they have received little consideration. Sixty per cent of these tumors are malignant (Thompson).

Etiology. As in testicular tumors, there are no constant etiological factors of importance.

Pathological changes. Tumors of the epididymis may be divided into the following classes:

- A. Benign tumors (25 reported by Thompson)
  - 1. Epithelial
  - 2. Mesoblastic
    - *a.* Lipoma
    - *b.* Fibroma
    - *c.* Myxoma
    - *d.* Leiomyoma
    - *e.* Endothelioma
  - 3. Heterologous tumors
    - *a.* Cystic dermoid
    - *b.* Cystic embryoma
- B. Malignant tumors (40 reported by Lazarus)
  - 1. Epithelial — carcinomata
  - 2. Mesoblastic — sarcomata
  - 3. Heterologous — malignant teratomata (including "seminome" of Chevassu).

Benign tumors. In this group many are of questionable origin since careful scrutiny shows that most of them arise from surrounding tissues or from the lower end of the vas deferens. Leiomyomata and vascular tumors are the most common types.

Malignant tumors. Lazarus collected 20 malignant epithelial tumors of the epididymis including 7 carcinomas, 4 squamous cell carcinomas and 8 adenocarcinomas including our case (Hinman and Gibson). He also tabulated 17 sarcomata of various types and 2 malignant teratomata. It may be that many of these tumors, both epithelial and mesoblastic, have a teratomatous origin. Malignant epididymal tumors metastasize by way of the lymphatics of the cord in a manner similar to that of tumor of the testis.

Diagnosis. The comparative rarity of these tumors and their close similarity to chronic inflammatory conditions have nearly always resulted, in the past, in an incorrect diagnosis until their true nature was revealed at operation or autopsy. The difficulty will be illustrated by citing a personal case of adenocarcinoma of the epididymis. The history and clinical picture were those of tuberculous epididymitis and, although the prostate and vesicular areas were negative, the presence of scrotal fistulæ and contracted scarred areas in the scrotum apparently clinched the diagnosis. The case was so typical of tuberculosis that the patient's age (78 years) was not considered of diagnostic importance. A conservative epididymectomy was done, and even at operation no doubt as to the nature of the disease was entertained. The pathologist's report of adenocarcinoma of the epididymis (see Fig. 27) subsequently came as a shock. Dr. Boehm of New York City, who referred the patient, operated on him again two years later for local recurrence and he was seen here again after another two years with a second recurrence in the skin of the scrotum. A radical resection of the area with castration was done (see Figs. 28 and 29). So far, there has been no evidence of metastasis.

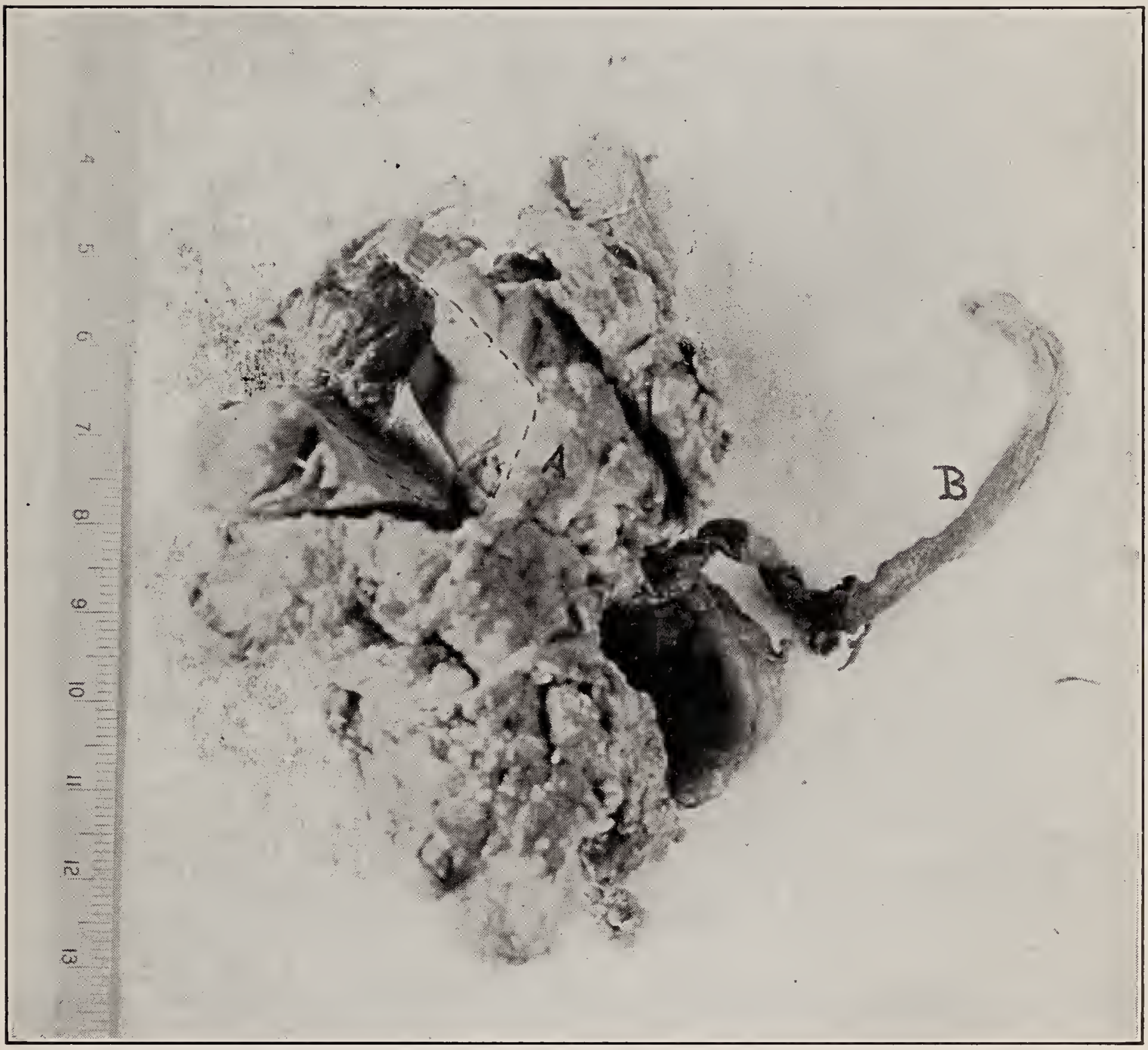

FIG. 27. Tumor mass involving epididymis with skin of scrotum adherent (A), and cord attached (B). The dotted line shows areas from which blocs were removed for microscopic study.

Ordinarily, differential diagnosis will not present such difficulties if one bears in mind the possibility of tumor. Mistaken diagnoses are usually made not because of defective history-taking or failure to do a careful physical examination but simply because the physician has not kept in mind all the possibilities.

It may be impossible to differentiate clinically between involvement of the testicle and epididymis in a given case, and, as the diagnostic points apply for the epididymis as well as the testicle, the reader is referred to the pages treating of the diagnosis of tumors of the testicle.

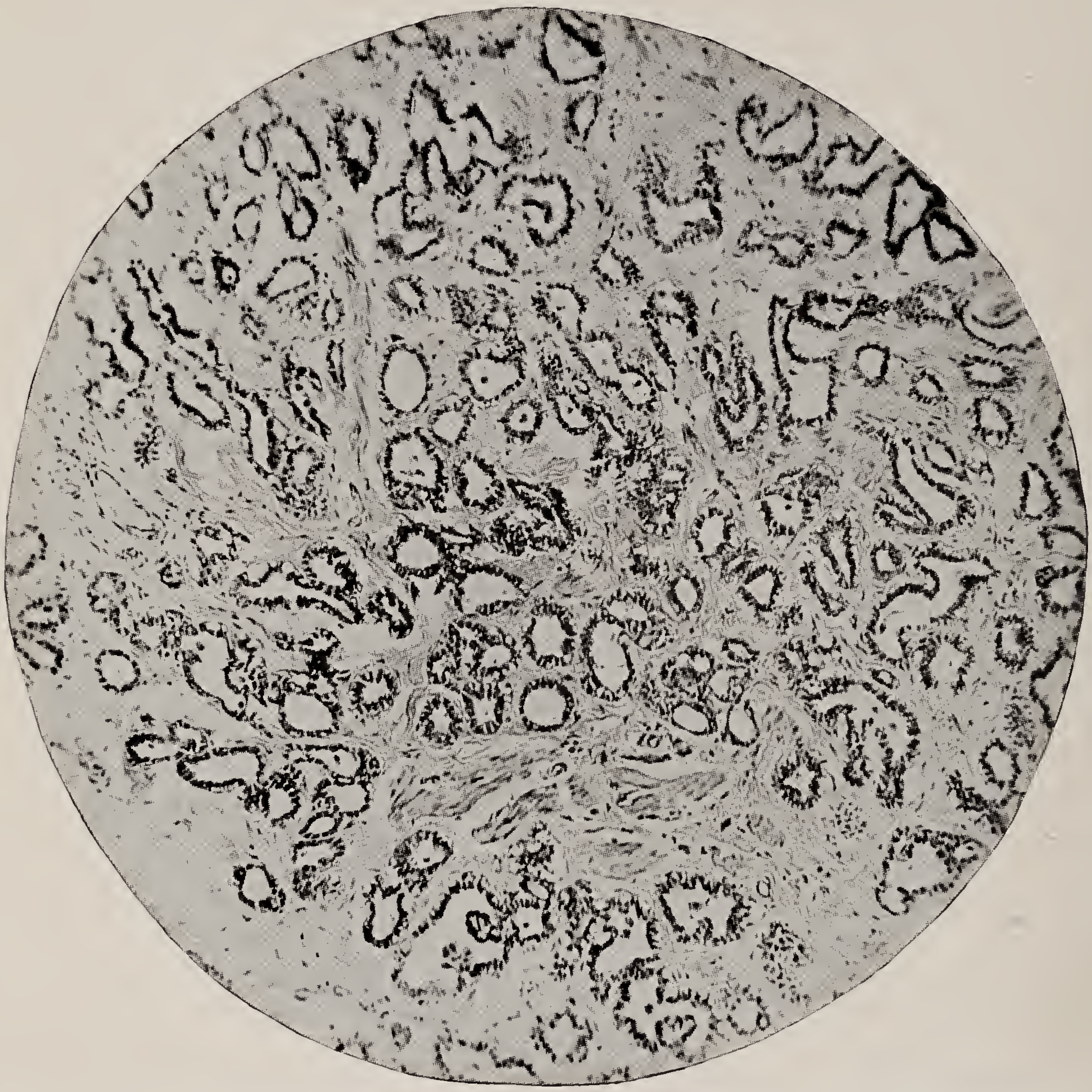

FIG. 28. Low-power microscopic view of tumor (Fig. 27), showing glandular type of proliferation, with dense intervening fibrous stroma. The epithelial cells are small and darkly staining.

Treatment. If tumor is suspected, there should be no hesitation in immediate surgical exploration. Since malignant epididymal tumors run a parallel course with those of the testicle, the same radical treatment is indicated.

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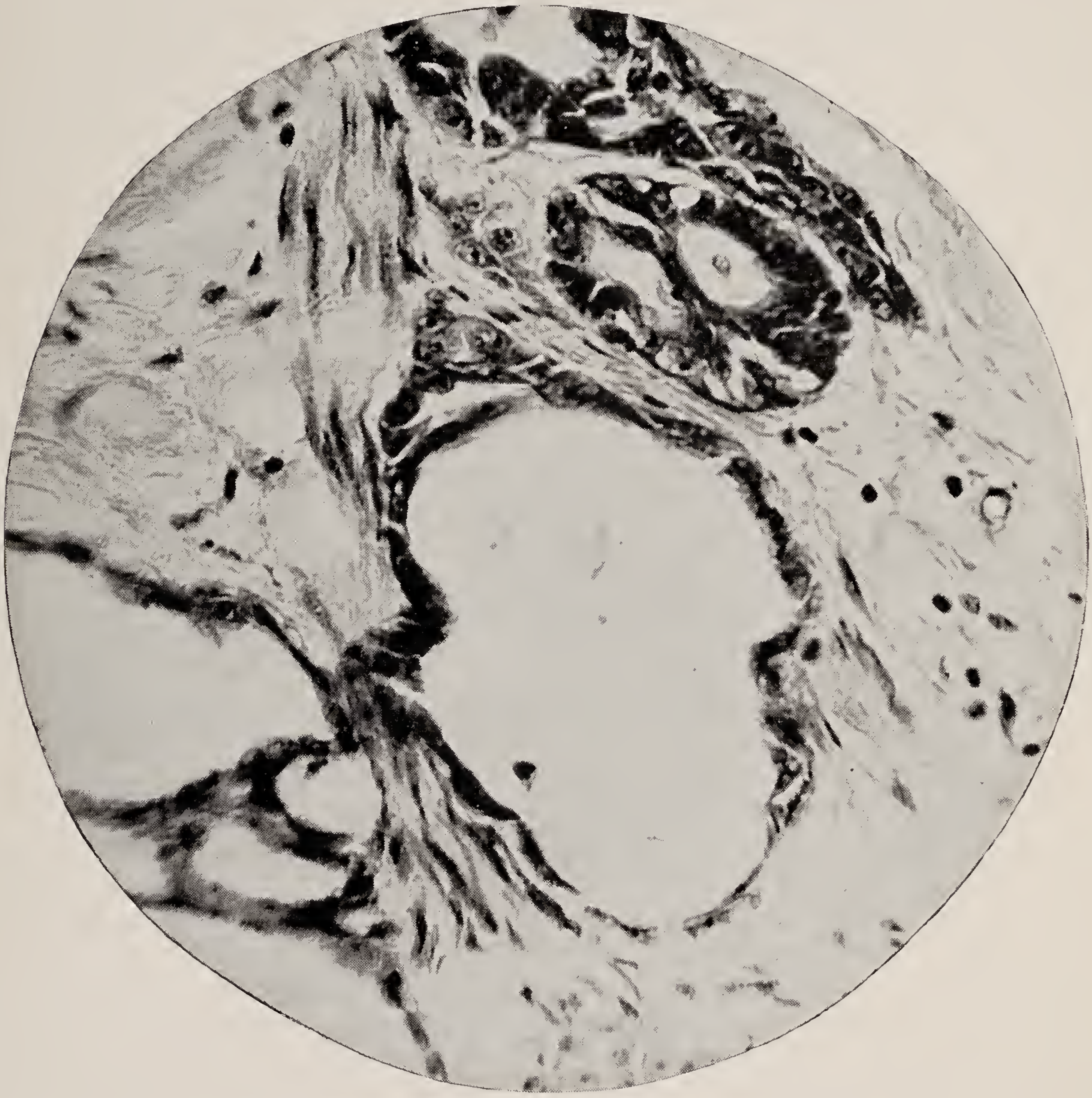

FIG. 29. High-power microscopic view of area shown in Figure 28. The cell types and character of proliferation may be noted.

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STERILITY IN THE MALE

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STERILITY IN THE MALE

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INTRODUCTION

Although male sterility had been recognized in Biblical times,[1] it was not until 1674 that Hamen[2] first saw spermatozoa in seminal fluid. This discovery was subsequently reported in a series of letters to the English Royal Society by Anton van Leeuwenhoek, who thought that a spermatozoon represented an entire embryo in miniature. He believed the rôle of the female to be that of a receptacle, and that the uterus was an incubator in which a spermatozoon developed into a full-grown embryo. For the next two centuries a philosophical controversy raged between the spermatists, the followers of van Leeuwenhoek, and the oovists. The latter maintained that the ovum was all-important and that spermatozoa were useless parasites. This feud was finally settled after the middle of the nineteenth century by von Baer's discovery of the mammalian ovum and by Hertwig's demonstration of a spermatozoon fertilizing an ovum. Since then, the innumerable studies which have been made of the generative organs and of the seminal fluid have contributed much to our morphological and physiological knowledge of fertilization and to our understanding of male sterility.

INCIDENCE OF STERILITY

It is difficult to estimate the general incidence of involuntary, or true, sterility because of the wide-spread use of contraceptives and because vital statistics do not include ectopic pregnancies, miscarriages, and induced abortions. Giles[3] states that "in England the ratio of sterility varies between 10 per cent. for workers to 16 per cent. for the leisured classes." Other workers in this field also estimate the percentage of childless marriages in this country and Great Britain at from 10 to 13 per cent.[4]

There has been a popular misconception that the female was by far the most frequent cause of childless marriage, as evidenced by the many Biblical and historical examples of monarchs vainly taking for themselves a second or third wife in order to establish a succession. However, in a series of 1000 males who were partners in sterile marriages, J. S. Read discovered abnormal spermatic fluid in 64 per cent. of the cases. Of these, 116 suffered from azoospermia and 522 from oligospermia.[5] After detailed study Meaker places the causative factors on the male side in one third of his 100 cases.[6] Hunner and Wharton[7] found that 56 of the husbands were sterile in 279 childless marriages. Others[88, 141] consider the male culpable, at least in part, in almost 50 per cent. of childless marriages. These statistics emphasize the importance of first examining the seminal fluid of the husband, before subjecting the wife to any extensive gynecological examinations.

ETIOLOGY OF STERILITY

ETIOLOGICAL CLASSIFICATION

A. Non-obstructive sterility
  1. General causes
    a. Dietary
      (1) Vitamin deficiency
      (2) Malnutrition
    b. Endocrine disorders
    c. Poisons
    d. Systemic diseases
  2. Local causes
    a. Faulty delivery
      (1) Impotence

- (2) Faulty sexual habits
- (3) Lesions of the urethra, such as stricture or hypospadias
- (4) Abnormality of the female
- *b.* Testicular lesions
  - (1) Congenital maldevelopment, undescended testes
  - (2) Operation and injury
  - (3) Syphilis
  - (4) Mumps and other inflammations
  - (5) X-ray and radium
  - (6) Thermal changes
    - (*a*) Elevated scrotal temperature
    - (*b*) Electrical physiotherapy
    - (*c*) Varicocele
  - (7) Neoplasm
- *B.* Obstructive sterility
  - 1. Epididymitis
    - *a.* Gonorrheal
    - *b.* Tuberculous
    - *c.* Non-specific inflammatory
      - (1) Bacterial
      - (2) Catarrhal
      - (3) Chemical
  - 2. Post-operative and post-traumatic lesions
  - 3. Congenital malformation
  - 4. Neoplasm
  - 5. Ejaculatory duct occlusion
  - 6. Lesions of the urethra

ETIOLOGY OF NON-OBSTRUCTIVE STERILITY

Nutrition and Vitamins

Darwin[8] has written that "the reproductive system can be shown to be susceptible to an extraordinary degree (though why we know not) to changed conditions of life." Investigations have revealed that the fertility of savages — as, for example, the Tasmanians, Maories, and Sandwich Islanders — is lessened by changes in their environment brought about by civilization. This is also true of other animals which have been taken from their natural wild state into captivity. Although this is undoubtedly due to a number of causes, it appears likely that changes and deficiencies in diet, especially a lack of vitamins, may play an important rôle. There is ample evidence that animals are better served by instinct than by scientifically calculated diet.

Vitamin E. Experimental evidence. Although it had been known that severe malnutrition or avitaminosis frequently resulted in lessened fertility, it was not until 1922 that Evans and Bishop[9, 10] were able to prove that a specific vitamin, now called vitamin E, was indispensable for reproduction in rats. These rats, fed on a diet free of vitamin E, but containing all other known food essentials and vitamins, at first showed a lessened degree of fertility and, finally, became completely sterile. These investigators had studied the sexual responses of male rats and had also examined the bouchon vaginale 5 minutes after coitus. They were able to recognize the following 4 changes: first, normal number of spermatozoa, loss of fertilizing power, and fairly normal sexual responses; second, complete loss of spermatozoa from the bouchon vaginale and sterility; third, loss of power to form the vaginal plug with or without retention of sexual responses; fourth, loss of all sex interest.

In like manner, Mason[11, 12] has found 5 progressive stages of testicular degeneration in rats fed on a vitamin-E-free diet. The end result was the disappearance of all the germinal epithelium, only some Sertoli cells and the connective tissue cytoplasm remaining. The germinal cells degenerated in the reverse order of their origin. The spermatozoa were the first to disappear, the spermatids next, followed later by the spermatocytes and spermatogonia.

From these observations, it may be concluded that, in rats, vitamin E deficiency results gradually in a loss of fertilizing power and sexual response, corresponding with demonstrable degenerative changes in the germinal epithelium. Absolute sterility, caused by vitamin E deficiency, remains permanent, thus proving the indispensability of this vitamin in the prevention of sterility.[13, 16]

Vitamin E and human sterility. Despite an increasing number of reports describing the beneficial effect of vitamin E administration in the treatment of habitual abortion[14, 15], there are no reported observations concerning the relation of vitamin E to human male sterility. Our experience is too small and recent to warrant any definite conclusions. In addition, it is virtually impossible to make an experiment on a sufficient series of sterile men with adequate controls. It is our impression, however, that the therapeutic value of vitamin E administration is decidedly limited for several reasons. Analogous to rats, azoospermia of any duration is usually accompanied by degeneration of the germinal epithelium, an irreparable change. It is also probable that very few individuals in the United States suffer from vitamin E deficiency, despite the widespread use of manufactured and canned foods. Although vitamin E is less abundant than other vitamins, it is found in fair amounts in muscle meat, uncooked green vegetables, especially lettuce, and corn oil, all of which are prevalent articles in the general diet of our country. Fresh wheat germ oil is the richest known source of vitamin E. The vitamin is destroyed, however, if the wheat germ oil becomes rancid or old.[16]

The Rôle of the Endocrine Glands

Although it is universally recognized that the hypophysis, the thyroid, and the suprarenal glands, and probably also the thymus, pancreas and pineal gland are closely related to the development and function of the gonads, an understanding of this inter-relationship is at present far from complete.

Anterior Hypophysis. Though Cushing and his co-workers[17] in 1910 had demonstrated the occurrence of atrophy of the reproductive organs following anterior hypophysectomy, it was not until 1927 that it was shown that hypophyseal implants would restore gonadal function in such animals.[18] It has also been demonstrated[19, 20] that the implantation of anterior pituitary tissue in immature mice or rats brings about maturation of the ovaries, or a marked growth of the seminal vesicles and prostate and stimulation of spermatogenesis. In like manner, injection of anterior pituitary extracts is followed by follicle development in hypophysectomized female rats and by marked growth of the testes and interstitial tissues in males. By these and many other observations, the intimate relationship of the anterior lobe of the hypophysis to the development and function of the ovaries, testes, and accessory reproductive organs has been demonstrated.

Hypophyseal gonadotropic hormones. It is now generally believed that the gonadotropic hormone of the hypophysis contains two fractions, a follicle-maturating hormone and a luteinizing hormone. Fevold, Hisaw, and their associates[21] have chemically fractioned dried powdered sheep's anterior pituitary into these two parts. The follicle maturating hormone stimulates the germinal epithelium. It produces spermatids and spermatozoa in immature animals and possibly also in hypophysectomized animals. The luteinizing fraction, on the other hand, stimulates the connective tissue elements, such as the interstitial cells of the testes and ovaries.

Pregnancy urine gonadotropic hormone (*prolan*). The discovery by Zondek and Aschheim of a gonadotropic hormone in the urine of pregnant women (prolan), erroneously believed at first to be a hypophyseal hormone, has led to some confusion. It is now fairly well established that prolan, as such, is secreted by chorionic tissue (placenta, chorionepithelioma, teratoma), and not by the hypophysis. While it is true that the behavior of prolan is in many ways similar to that of the hypophyseal gonadotropic hormones, certain biological differences have been demonstrated. Prolan gives effects like those of the luteinizing fraction of the pituitary hormone in hypophysectomized animals. It does not stimulate the growth of ovarian follicles, nor does it influence the development of the immature avian testis in the absence of the pituitary. In hypophysectomized animals, prolan is less efficacious than hypophyseal implants or than extracts of the whole anterior substance, giving only a partial effect.[22, 23, 24, 25] Prolan is, therefore, called the anterior-pituitary-like hormone (A. P. L.)

However, in seeming contradiction, it has been experimentally demonstrated that prolan also stimulates the germinal epithelium.[26, 27] Although this effect has been denied by Collip,[28] it has been confirmed by Evans and his co-workers.[29] This action of prolan on the spermatogenic tissues has been further confirmed clinically by our observations, and by those of Brosius and Schaffer,[30] Lloyd,[31] and others.[32, 33] This stimulating effect on the germinal epithelium may be due to an additional follicle maturating fraction in the pregnancy urine extract.

Castrate and post-menopausal gonadotropic hormones. Gonadotropic hormone obtained from the urine of women after the menopause, or from castrates, is believed to be identical with the anterior pituitary hormone. Its presence in considerable amount in such urine is explained by increased secretion of the hypophysis after the inhibiting action of functioning ovaries is removed. In immature rats, mice, or monkeys[34, 35], the injection of castrate or post-menopausal urine extract is followed by maturation of the follicles, and sometimes by corpus luteum formation. In hypophysectomized animals, it causes stimulation of the seminiferous epithelium.[22] These are believed by some to be its sole effects.[24] However, the investigations of Frank, Goldberger, and Salmon[36] have shown that the luteinizing fraction is also present in excess after the menopause.

A gonadotropic hormone has been discovered in the serum of mares during the middle period of pregnancy. Injection of this hormone is said to restore gonadal function after hypophysectomy. Both the germinal epithelium and the interstitial tissues are stimulated.[22]

The anterior hypophysis in man secretes gonadotropic hormones which are necessary for the development and maturation of the testes, the ovaries, and other reproductive organs. The hypophyseal gonadotropic hormone appears to be identical in both sexes.

Clinical disorders of the hypophysis. In hyperpituitarism, such as gigantism or acromegaly, there may be at first a stimulating effect on sexual function. However,[37] at a later stage, sterility and impotence usually intervene. In gigantism the gonads are sometimes hypoplastic and secondary sexual characteristics absent. On the other hand, some patients suffering from gigantism, or from partial or arrested acromegaly, may reproduce quite normally. Radiotherapy and surgical intervention have at times successfully arrested the symptoms of hyperpituitarism. Whether such therapy will prevent absence or loss of gonadal function has not as yet been determined.

Pituitary hypofunction leads to obesity and hypogonadism, dystrophia adiposogenitalis (Fröhlich's syndrome). The penis is small, and the testes are underdeveloped and not infrequently undescended in these young men. Frequently, the seminal fluid shows complete absence of spermatozoa. The less marked degrees of hypopituitarism manifest themselves by a diminution in number, motility, and vitality of the spermatozoa.

Thyroid gland. The rate of metabolism is primarily controlled by the thyroid gland. With increased function (Graves' disease), there is a corresponding increase in metabolism and excitability. In the early stages, an increase in libido is frequently noted. In the more advanced stages, however, sexual desire and vigor frequently are lessened or lost.

Thyroid hypofunction, on the other hand, decreases the rate of metabolism. This is frequently accompanied by a diminution in sexual drive and fertility. In congenital hypothyroidism (cretinism) gonadal development is usually arrested, the testes and penis remaining hypoplastic. Libido is diminished or absent. Zondek,[37] however, has reported a case of congenital myxedema in which the penis was long and broad, the testes large, and libido pronounced.

Relationship of thyroid to hypophysis. Marine[38] has stated that "the effects of the thyroid on the gonads, and vice versa, could be explained as effects mediated through the anterior pituitary." For example, thyroidectomy in rabbits at puberty produces hypertrophy of the anterior pituitary and an increase in the gonadotropic hormones. The administration of thyroxin, on the other hand, lessens the secretion of hypophyseal gonadotropic hormones and tends to suppress the sexual cycles.

Suprarenal glands. *Experimental evidence.* The suprarenal glands of animals increase in size following the removal of the ovaries and, to a lesser extent, following bilateral orchidectomy. Conversely, Jaffe and Marine[39] have demonstrated an increase in size of the ovarian follicles of rabbits following suprarenalectomy. They were, however, unable to find constant changes in the interstitial cells or in the tubules of the testes.

Previous reports of testicular atrophy in suprarenalectomized animals have thus been open to question.[40] It is now generally recognized that an intimate relationship exists between the suprarenal cortex and the development of the gonads.

The sexual development of immature suprarenalectomized rats is belated and insufficient. The testes, prostate, and seminal vesicles are small, spermatogenesis being slight or absent. On the other hand, precocious sexual maturity has been induced in immature animals by the injection of suprarenal cortical extracts.[41]

Clinical evidence. These animal experiments have been confirmed by clinical observations of precocious sexual development in children suffering from suprarenal cortical tumors. On the other hand, the action of the suprarenal cortex appears to be inhibitory in adults. This has been confirmed clinically in women whose menstruation and other sexual functions have ceased with suprarenal cortical hyperfunction.[37, 42, 43, 44] A return of the normal female sexual functions following surgical removal of suprarenal cortical tumors has been observed by Cahill, Loeb, and their co-workers.[44] No similar cases have been reported in males.

Addison's disease is often accompanied by testicular atrophy and a loss of secondary sexual characteristics.

Relationship of suprarenals to hypophysis. The close relationship between the suprarenals and the pituitary suggests that the action of the suprarenals on the gonads may be through their influence on the hypophysis, rather than a direct one. For example, after hypophysectomy the suprarenal cortex atrophies. With the administration of anterior pituitary extract, regeneration takes place. Conversely, destruction of the suprarenal cortex results in atrophy of the anterior hypophysis, especially of the basophilic cells. Oppenheimer and Fishberg[45] have reported an autopsied case of suprarenal cortical carcinoma with acromegalic features. On the other hand, one of the classical signs of basophilic adenoma of the hypophysis is hirsutism, which is also a manifestation of suprarenal cortical hyperfunction.

Testes. *Male sex hormone.* In addition to the function of spermatogenesis, the testes produce an internal secretion by means of their interstitial cells. This internal secretion controls the development of the secondary sexual characteristics as well as the growth of the accessory sexual organs, such as the prostate and seminal vesicles. It also inhibits castration changes in the hypophysis.

Although Brown-Sèquard[46] had made crude dilute saline extracts of testicular tissue, it was not until the last decade that decided advance was made in the biochemistry and extraction of the male sex hormone.

of the causative factors. Not uncommonly, however, faulty sexual habits, such as coitus interruptus, excessive masturbation, or incomplete ejaculation will cause congestion of the posterior urethra and inflammatory swelling of the verumontanum, often resulting in impotence.

Faulty sexual habits. It has been stated above that excessive masturbation, unnatural coitus, and coitus interruptus may often lead to physical lesions, such as congestion and inflammation of the verumontanum, catarrhal urethritis, prostatitis, seminal vesiculitis, and epididymitis. These lesions may later result in occlusion of the ejaculatory ducts or epididymes, true obstructive sterility. On the other hand, catarrhal prostatitis and seminal vesiculitis are a frequent cause of necrospermia and oligospermia. Plugs of mucus, pus, and debris may plug the ejaculatory ducts, preventing the free egress of seminal fluid during ejaculation.

It is doubtful whether over-indulgence in normal coitus can occur. Desire and potency are generally lost before harm can take place. Continence also does not appear to exert any ill effect on the spermatogenic function. Serial vaso-seminal vesiculograms, made in abstinent castrated men, have demonstrated that the seminiferous tract empties itself of iodized oil at a slow constant rate.[62] The occurrence of spermatozoa in 73 per cent. of successive daily urine specimens of continent men, examined by A. W. Seligmann, Jr. and the writer,[63] further corroborates these findings. This slow regular emptying of the seminiferous tract, in addition to nocturnal and diurnal emissions, appears an adequate mechanism whereby the body rids itself of the excess spermatic fluid which is constantly being formed in normal adult life. This agrees with the frequent clinical observation that in the absence of harmful sexual habits, premarital abstinence does not impair fertility.

Lesions of the urethra. Abnormalities of the urethra, such as hypospadias and epispadias, not infrequently interfere with proper ejaculation of the seminal fluid and may thus mechanically cause sterility. A minor degree of hypospadias can change the direction of the emission, preventing the seminal fluid from being ejaculated into the cervix.

In like manner, a tight urethral stricture often hinders, and may even prevent, ejaculation. Such a case has been cited by John Hunter.[64] His patient had frequently noticed that no semen appeared at the meatus during nocturnal emissions, and had stated that he felt the fluid going backward into the bladder. At other times, however, the seminal fluid passed forward normally through the penis. The same sensations and pleasure were experienced when the semen went back into the bladder as during normal emissions.

Abnormality of the female. Obstructive lesions of the female genital tract, such as imperforate hymen, stricture, or atresia of the vagina, or cervical stenosis will obviously interfere with the proper delivery of the seminal fluid into the cervical canal. Vaginospasm may likewise make coitus impossible.

Testicular Lesions

Undescended testes. The testes of adult men and of experimental animals when retained in the abdominal cavity show a loss and degeneration of the germinal epithelium.[65] As a result, they do not usually produce spermatozoa. Instances of fertility have, however, been occasionally reported despite the presence of bilateral undescended testes. Indeed, Uffreduzzi[66] has estimated that 10 per cent. of the tubules in cryptorchids are capable of producing spermatozoa. The absence or diminution of spermatogenic function is believed to be due to the elevated temperature of the tissues surrounding the abnormally situated testes, the intra-abdominal temperature having been shown to be from 5 to 8 degrees higher than the scrotal temperature. Moore and Fukui[67, 68] have ascribed the function of thermal regulation to the scrotum.

It is important, therefore, from the point of view of spermatogenesis that undescended testes be placed in the scrotum prior to or at puberty. In a series of 22 patients operated on for bilateral cryptorchidism before puberty, MacCollum[69] found, later in life, evidence of definite fertility in 15 and potential fertility in 3 patients. He concluded that the operative replacement of undescended testes into the scrotum prior to puberty greatly increases the chances of fertility.

Syphilis. Pathologically, syphilis of the testis may be divided into two general types:[70, 71]

1. Interstitial fibrotic orchitis
2. Gummatous orchitis

It occurs in both the congenital and the acquired forms, predominantly in the late stages of the disease. Since the introduction of the present-day methods of intensive anti-luetic treatment, testicular syphilis is but rarely encountered. With increasing destruction of the testis, its spermatogenic power is lessened and ultimately destroyed.

Mumps. The incidence of orchitis varies in different epidemics.[74] Ballenger and Elder[72] have estimated that it occurred in from 10 to 25 per cent. of cases of mumps. Orchitis results in testicular atrophy in slightly more than half of the cases. Fortunately, however, the disease is frequently unilateral and the atrophy of the germinal epithelium is not always complete. This accounts for the relative infrequency of sterility following mumps orchitis.[73]

Other inflammations. Acute orchitis occurs occasionally during the course of certain acute infectious diseases, such as small-pox[74, 84] and typhoid fever.[75] More rarely has it been observed in typhus fever, gout,[76] diphtheria, malaria, and acute rheumatic fever.[77] Orchitis may also be caused by the pyogenic cocci[75] and the colon bacillus. Such lesions may be metastatic, being carried through the blood stream. More commonly, the organisms may be borne through the lumen of the vas deferens or its lymphatics following posterior urethral infections and trauma. Pyogenic coccal infections frequently result in abscess and loss of the testis.

X-ray and radium. The deleterious effects of x-ray on the germinal epithelium have been known since the work of Albers-Schönberg[78] in 1903. The spermatogonia are especially radio-sensitive. Spermatozoa, however, are more resistant. Complete atrophy of the germinal epithelium is the end result of prolonged exposure to x-ray. Similar changes have been reported by Regaud,[79] following exposure of the testis to radium. The interstitial tissues, on the other hand, are much more resistant.

Thermal changes. The testes are known to be highly sensitive to changes in temperature. Temporary sterility has been observed in rams wearing an insulating scrotal suspensory.[65, 80] Undescended testes, which are in a warmer environment than the scrotum, do not generally produce spermatozoa. By exposing the scrotum to a constant stream of hot water, Moore, Young, and Fukui[67, 81, 68] have experimentally produced degenerative lesions of the germinal epithelium in guinea pigs. On the other hand, A. Schwartz and the author have been unable to find histological changes in the germinal epithelium of guinea pigs following intense and prolonged exposure of the testes to short-wave therapy. It seems reasonable, however, that the chronic passive congestion caused by varicocele, with its concomitant elevation of temperature and nutritional changes, may cause a loss of spermatogenic function and finally atrophy of the germinal epithelium.

Varicocele. The importance of varicocele as a factor in the etiology of partial and absolute sterility is commonly underestimated. Although a slight degree of varicocele may be found in the majority of adults, the incidence of pathological varicocele is given at from 1 to 5 per cent. This variation is due largely to differences of interpretation as to what constitutes a pathological degree of varicocele.

In my series of 30 patients suffering from non-obstructive sterility, 1 moderate-sized and 8 large varicoceles were encountered (30 per cent.). Eight were on the left side and 1 was bilateral. In an analysis of 100 sterile couples Meaker[6] has likewise noted a high incidence of varicocele.

The importance of varicocele in the causation of sterility was recognized by Gosselin[82] who observed diminution in size of the testis accompanied by a left varicocele. This patient developed later a severe right gonorrheal orchitis. Thereafter, no spermatozoa were found in his seminal fluid. Somewhat later, Curling[83] reported a case of bilateral varicocele and one of left varicocele and right epididymitis in each of which azoospermia was found.

There is some question as to the frequency of testicular atrophy as a result of varicocele. Paget[76] and others considered it rarely, if ever, present. On the other hand, Curling, Will,[85] and others[70, 86] believed that varicocele tends to impair the nutrition of the testis and, consequently, its spermatogenic power. In a series of 403 cases Barney[87] found testicular atrophy in 11.5 per cent.

The majority of men suffering from varicocele are fertile, since it usually affects but one side. Only cases of bilateral varicocele, and those cases of unilateral varicocele with impaired or absent function of the other testis, will show evidence of deficient spermatogenesis. Examinations of seminal fluid have rarely been reported in cases of varicocele. Grossly demonstrable alterations in size, consistency, and sensibility of the testis are not found in most cases. However, since varicocele causes circulatory stasis with accompanying changes in the temperature and nutrition of the testis, an impairment of spermatogenic function may occur long before gross changes can be detected.

Neoplasm. Neoplasms infiltrating the testis will obviously destroy both its internal and external secretory function. For a comprehensive discussion of testicular tumors, the reader is referred to Hinman, The Testicles and Epididymes, Oxford Urological Surgery, Volume I, 746 (192).

ETIOLOGY OF OBSTRUCTIVE STERILITY

Obstruction of the seminiferous tract may occur at any point from the rete testis to the mouth of the ejaculatory duct in the posterior urethra. Obstruction in the urethra due to stricture has been already discussed (page 746 (298–15A).

Although obstructive sterility is most often due to bilateral epididymitis, it may also be caused by occlusion of the vasa deferentia or of the ejaculatory ducts. The determination of the site of the blockage is of great practical importance, since anastomotic operations cannot succeed unless the vas deferens and ejaculatory duct are patent from the point of anastomosis into the urethra. Obstructive sterility may be due to congenital malformation, inflammation, trauma, and, rarely, to neoplasm.

Epididymitis. Gonorrheal epididymitis is by far the most frequent cause of obstructive sterility. Benzler[88] found in the German army that 38.7 per cent. of the men who had suffered from bilateral epididymitis were childless. In addition, 25 per cent. of those who had suffered from unilateral gonorrheal epididymitis were also sterile. Of 116 cases of azoospermia reported by Read,[5] 62 per cent. were due to the after-effects of gonorrhea, 20 per cent. to other infections, and 15 per cent. to congenital malformations. Bilateral gonorrheal epididymitis was present in 34 of these cases.

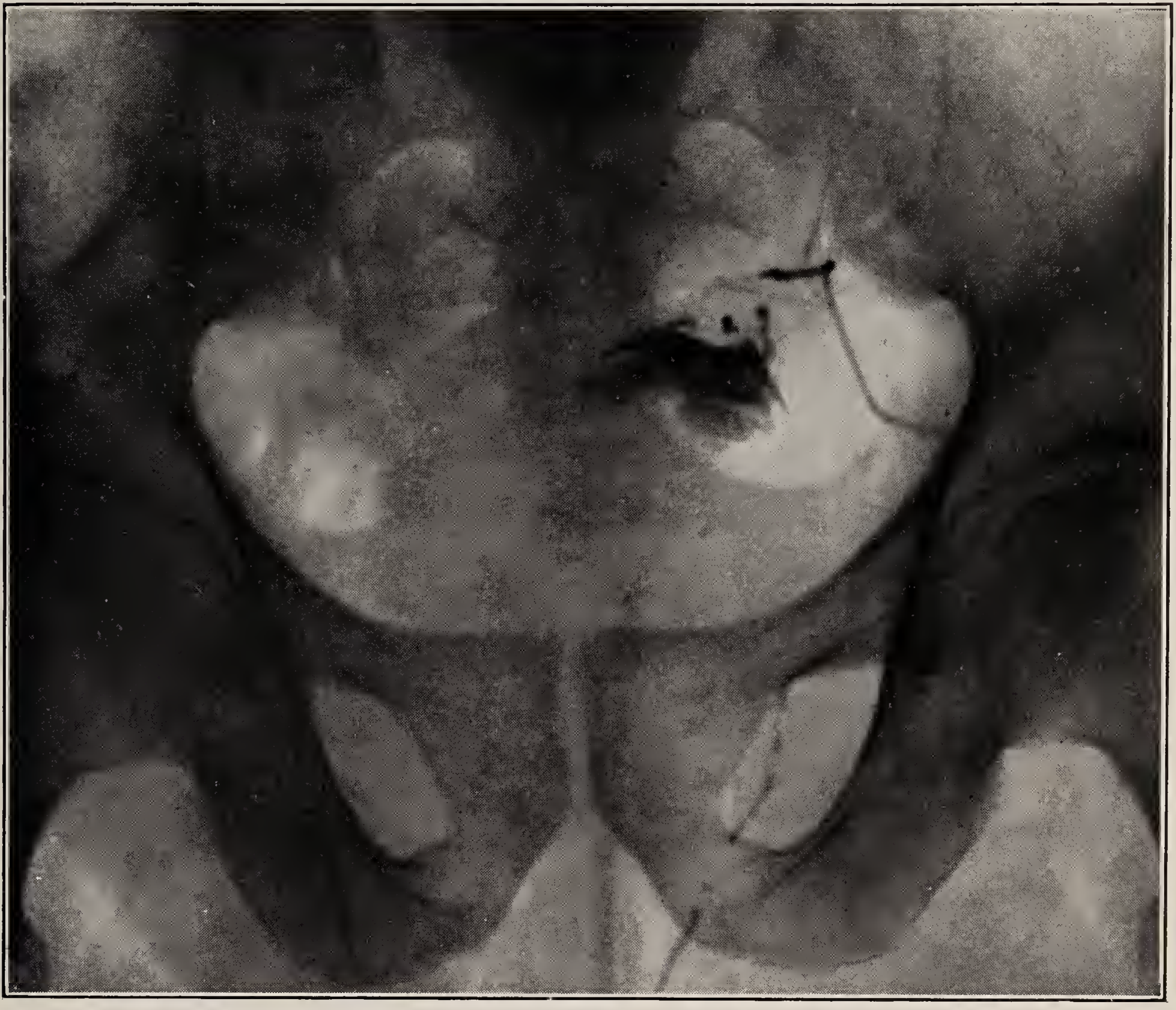

FIG. 1. Vaso-seminal vesiculogram, showing chronic colon bacillus abscess of the seminal vesicles.

Non-specific bacterial infection, tuberculosis, and trauma may also be the cause of bilateral epididymitis resulting in sterility. Non-specific bacterial infections may follow urethral instrumentation, irrigation, or faulty sexual habits. Occasionally, bacterial epididymitis may be metastatic, the infective organisms being carried by the blood stream.

Operative trauma. Obstructive sterility occasionally results from a surgical accident. In the course of a hernioplasty or hydrocele operation the vas deferens may be inadvertently ligated or severed, or a secondary epididymitis may occur. More rarely ill-considered vasectomy in younger men may require re-anastomosis. Cases of fibrotic occlusion of the vas deferens may be expected as a result of the recent revival of the chemical injection treatment for hernia.

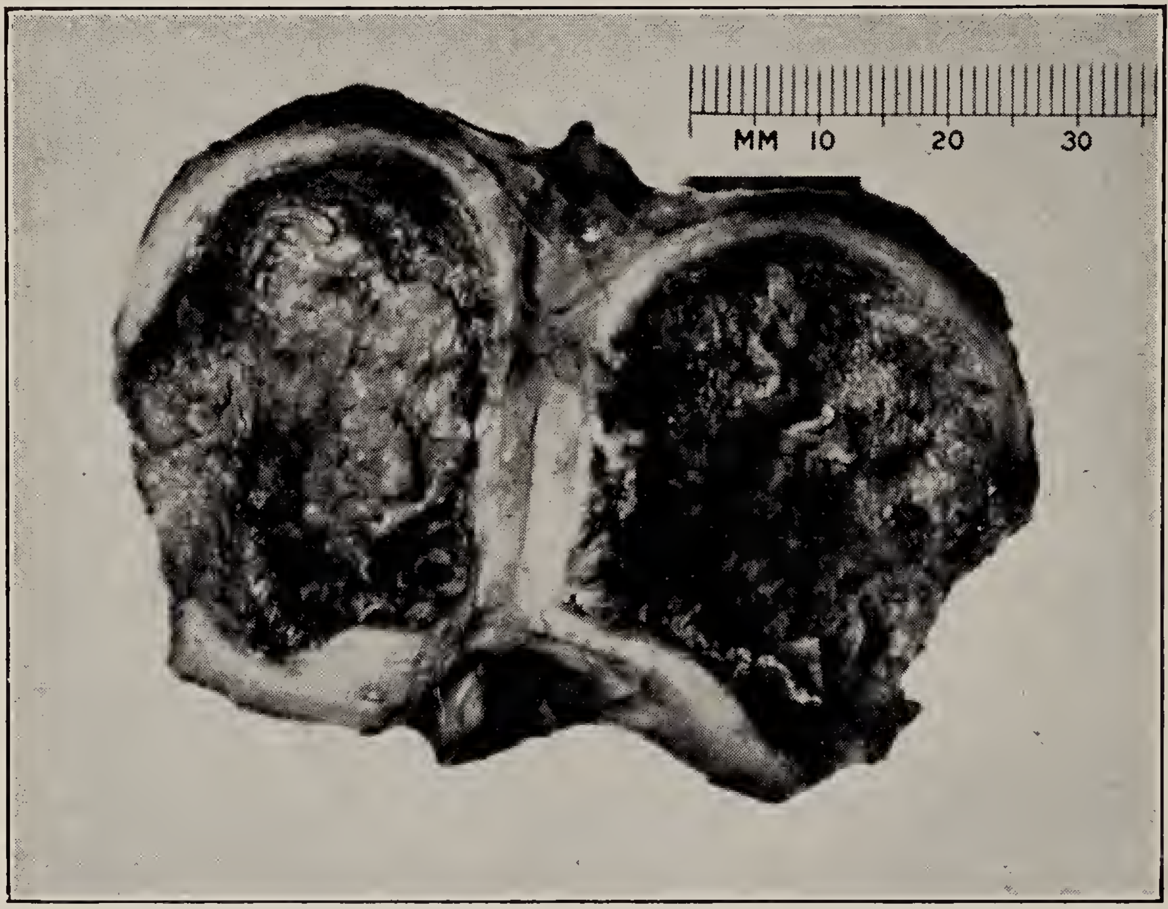

FIG. 2. Surgical specimen: chronic abscess with fusion of both seminal vesicles (See Fig. 1).

Many cases of epididymitis are accompanied by vasitis, seminal vesiculitis, and prostatitis. The testis, itself, however, is usually spared. It has been established that its germinal epithelium is capable of function for many years after the epididymis or vas deferens has been occluded.

Obstruction of the ejaculatory ducts. Ejaculatory duct obstruction may be congenital or due to injury, inflammation, or neoplasm. A case of chronic colon bacillus abscess of the seminal vesicle, following urethral instrumentation, has been reported by the author.[89] Vaso-seminal vesiculograms and the surgical specimen, removed transperitoneally, revealed fusion of the seminal vesicles into one abscess sac, which did not communicate with the urethra (Figs. 1 and 2). In like manner, tuberculous abscess of the seminal vesicle with ejaculatory-duct occlusion was demonstrated in 2 cases (Fig. 3). Obstruction of the ejaculatory ducts by prostatic carcinoma is probably not uncommon.

Of great practical interest is the occurrence of ejaculatory-duct blockage following transurethral prostatic resection. The author has seen 1 such case. The patient complained that there was no emission with orgasm. A left vaso-seminal vesiculogram revealed a normal vas deferens and seminal vesicle. The ejaculatory duct, however, was not visualized, nor had any iodized oil entered the urethra. Serial seminal vesiculograms, made for a period of 6 months following injection, showed complete retention (Fig. 4). There was no emptying into the urethra despite repeated orgasms and seminal-vesicular massage.

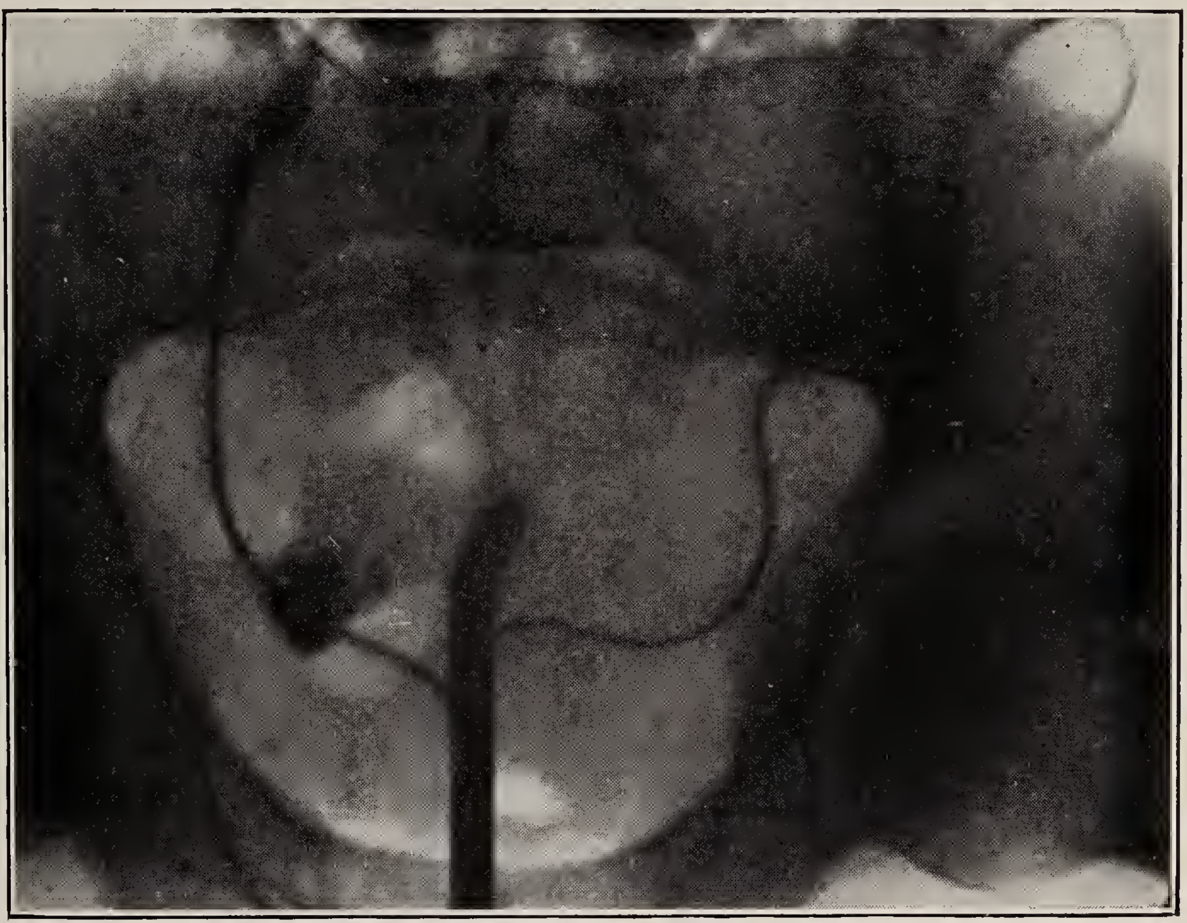

FIG. 3. Seminal vesiculogram, demonstrating tuberculous abscess of the seminal vesicle with ejaculatory-duct occlusion. Note also the relation of the seminal vesicle to the ureter.

Non-obstructive pathological lesions of the ejaculatory ducts can also be demonstrated. Loss of sphincteric control, associated with dilatation of the ejaculatory duct permitting reflux from the posterior urethra, has been seen in 4 cases. One of these was following suprapubic prostatectomy. The remaining 3 occurred in patients suffering from tuberculosis of the epididymis and seminal vesicle (Fig. 5). In these cases unilateral vaso-seminal vesiculography was performed during the course of prophylactic vasectomy on the healthy side. The excess iodized oil, which emptied into the posterior urethra, flowed refluxly up the other pathologically dilated ejaculatory duct, clearly outlining it, as well as the corresponding ampulla and seminal vesicle.

These initial observations indicate the possibility for clear demonstration of ejaculatory-duct lesions in cases of obstructive sterility.

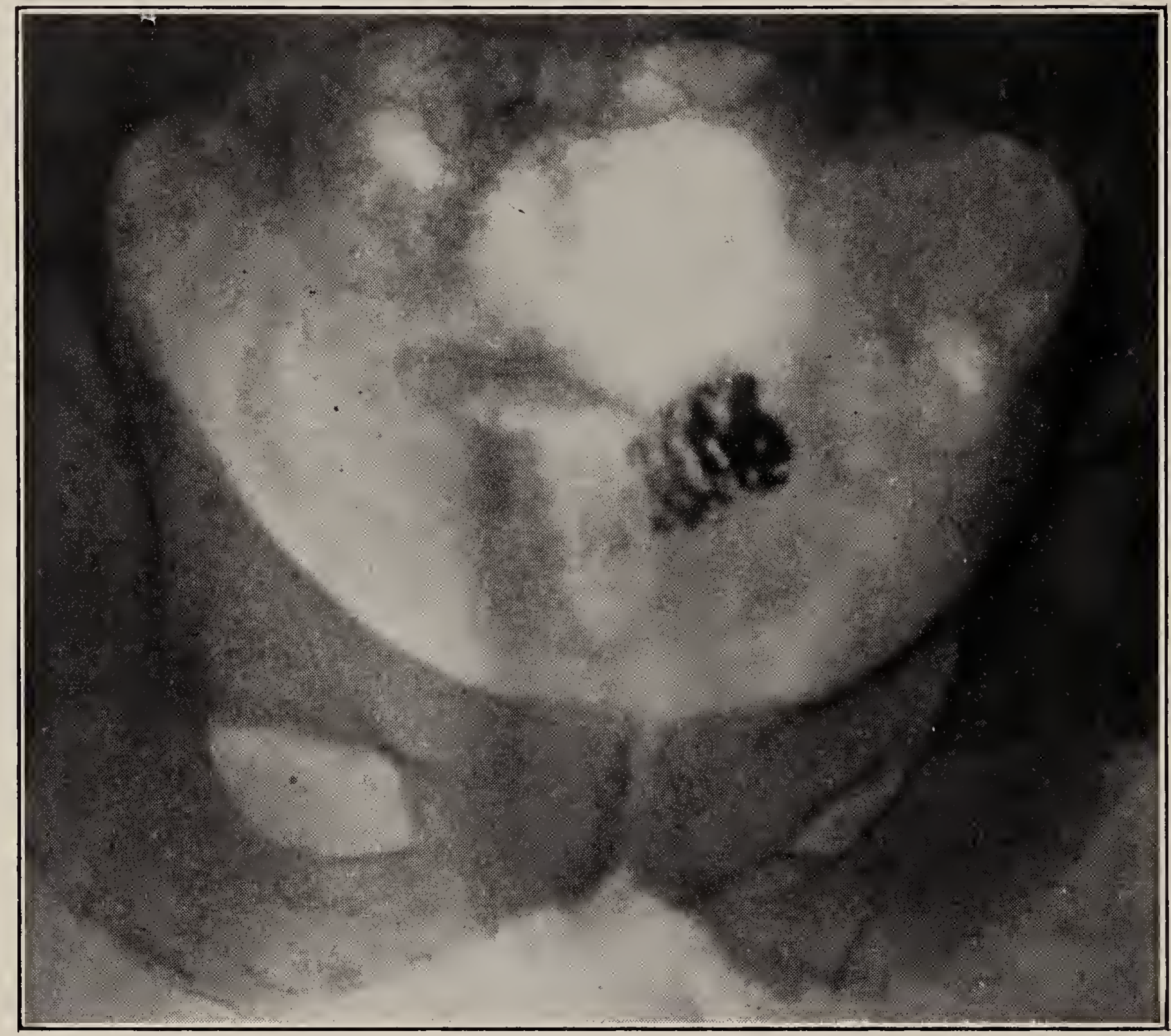

FIG. 4. Vaso-seminal vesiculogram 6 months after transurethral prostatic resection. There is complete retention in the seminal vesicle due to ejaculatory-duct occlusion.

Temporary ejaculatory-duct obstruction may be caused by plugs of debris, mucus, or pus, as well as by edema and inflammation of the posterior urethra.

MULTIPLICITY OF CAUSATIVE FACTORS IN STERILITY

Loss of fertility is not uncommonly due to a single cause, such as bilateral gonorrheal epididymitis, testicular atrophy following mumps, or undescended testes. Frequently, however, a number of factors are operative in the causation of sterility. For example, one of our patients had a large left varicocele and a right undescended testis. Either of these lesions alone might not have interfered with the procreative ability of the patient. In like manner, a second patient suffered from both a left varicocele and hypophyseal deficiency. The administration of prolan resulted in but slight improvement of the seminal fluid. Following corrective operation for varicocele, there was an immediate diminution in the number and motility of the spermatozoa. However, with additional prolan therapy and a 6 months' time interval, the number and motility of the spermatozoa reached an approximately normal level. Impregnation occurred.

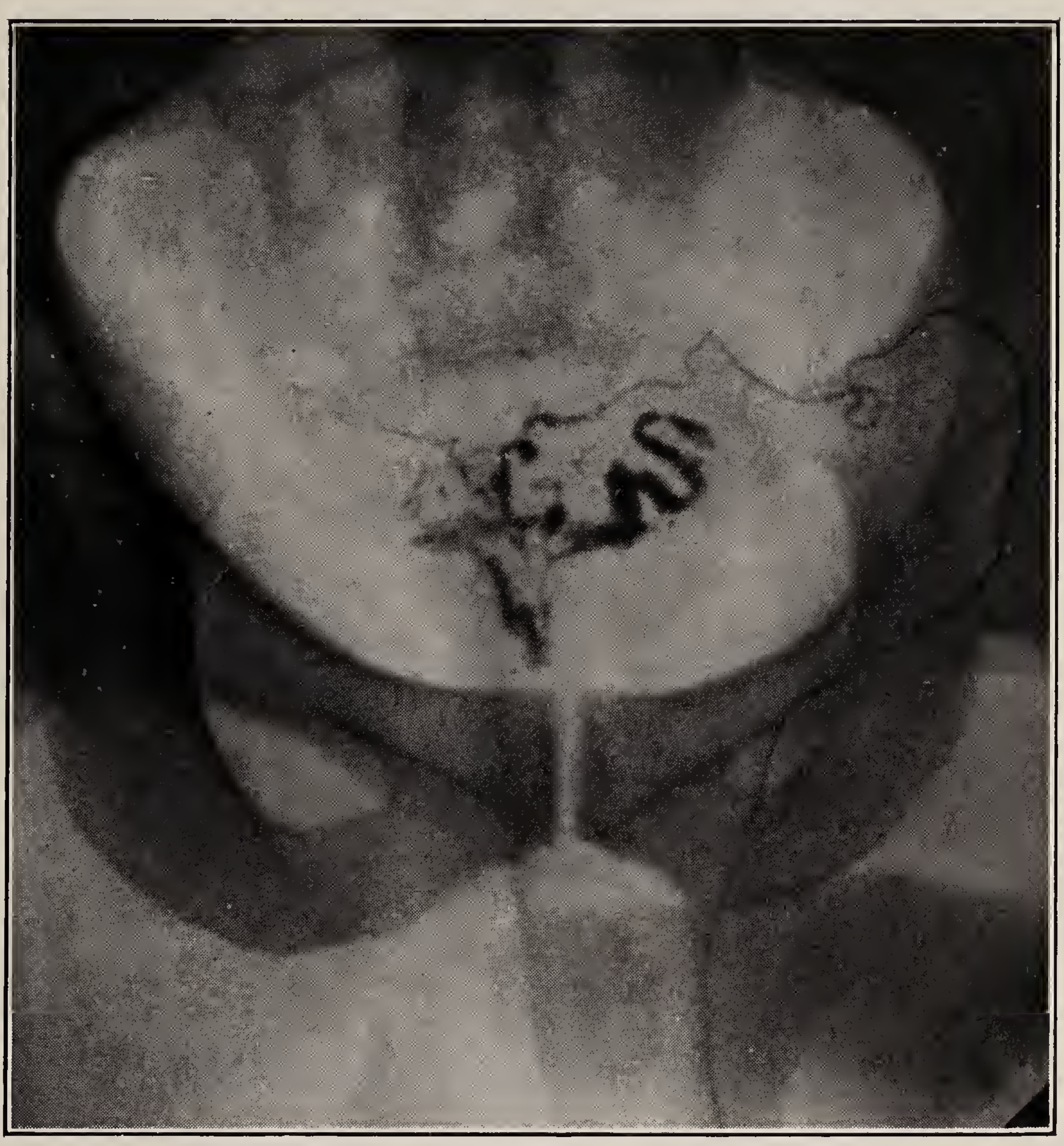

FIG. 5. Normal left vaso-seminal vesiculogram. Note the reflux of iodized oil up the greatly dilated right ejaculatory duct into the vas deferens. Diagnosis: tuberculosis of right seminiferous pathways.

Such cases emphasize the necessity for complete study of every sterility patient. The finding of one etiologic sterility factor should not deter the investigator in his search for others.

DIAGNOSIS OF STERILITY

Sterility may be absolute or relative. Men who are relatively sterile may be able to impregnate highly fertile women. Statistically, however, their chances are less than those of the normally fertile.

The diagnosis of sterility may be considered in 3 parts:

1. The examination of the seminal fluid.
2. The examination of the male, including the history, general physical and urological examination, and laboratory tests.
3. The examination of the female, including the Hühner test.

THE EXAMINATION OF THE SEMINAL FLUID

Gross and microscopic examination of the seminal fluid is the initial step in the investigation of a childless couple.

Collection of seminal fluid. A specimen may be obtained either by masturbation or by coitus with a condom. More rarely, spermatozoa may be expressed by prostato-seminal-vesicular massage. This can be done in fertile men whose seminiferous tract is well filled as a result of abstinence. It is quite common, however, to find but few or no spermatozoa in the prostato-vesicular secretion of fertile men. Therefore, an absence or diminution in the number of spermatozoa may be of no significance. For purpose of diagnosis, prostato-vesicular secretion is of value only if many motile normal spermatozoa are found.

Seminal fluid secured by masturbatory ejaculation is adequate and has the advantage of immediate examination. The total quantity is usually less than that obtained by coitus.

Post-coital condom specimens should be transferred to a dry clean glass bottle and transported to the microscope as rapidly as possible. Elaborate methods have been used by some to keep the seminal fluid at body temperature during transportation. Others have recommended chilling the semen and later reheating it to 37 degrees C. just before the microscopic examination. These precautions are generally unnecessary and sometimes even harmful. Specimens have not infrequently been over-heated, with resultant loss of spermatozoal motility. Patients are routinely instructed to wrap the specimen bottle in cotton or paper and to deliver it within an hour. This method has been generally satisfactory. In doubtful cases, examination may be repeated with more rigid technic as to temperature and time.

Because of normal variation, at least 2 or 3 seminal-fluid specimens must be examined in all cases before a definite diagnosis can be made.

It is advisable for patients to abstain from coitus for 3 to 7 days before each seminal-fluid examination.

Gross examination of seminal fluid. The seminal specimen, normally a mixture of testicular, epididymal, seminal vesicular, prostatic, and accessory glandular secretions, is first grossly examined in regard to amount, color, and consistency. The average amount of a normal ejaculation after several days' rest is from 3 to 6 cc. Fresh seminal fluid is opaque, whitish in color, and viscous. It contains a mucus gelatinous portion which dissolves after a short time. Seminal fluid is alkaline, the *p*H varying usually between 7.7 and 8.5. Determination of the hydrogen ion concentration appears to have little clinical importance, although Hotchkiss[90] has found in rare instances a low reading of about 6.0 associated with necrospermia.

Microscopical examination of seminal fluid. A wet drop of seminal fluid is then examined under the low and high dry objectives for number, motility, morphology, and vitality. Normally, the field is teeming with countless actively motile spermatozoa. With limited experience one can easily recognize any appreciable diminution in numbers or motility. The observer should carefully note the percentage of non-motile spermatozoa, as well as the morphology of the heads and tails. Minute measurements of the spermatozoa of bulls have been made by Williams and Savage,[91] who believe that abnormalities in size and shape of the heads are of great significance. Moench[92, 93, 94] has estimated that up to 20 per cent. of the spermatozoa heads may be abnormal in the seminal fluid of fertile men. In those who were sterile, he found that the proportion of abnormal heads rose to 25 per cent. Abnormalities of the tails, such as sharp angulation, coiling, reduplication, and absence, although occasionally seen in fertile men, may be considered an indication of lessened fertility if frequently found. It may be concluded that an increase in the number of abnormal spermatozoa should be regarded as an indication of relative sterility. In addition, the observer should note the presence of abnormal cells, such as leucocytes, erythrocytes, as well as bacteria, debris, and crystals.

As the seminal-fluid drop dries, the spermatozoa lose their motility. Therefore, the vitality, or the duration of motility of the spermatozoa, must be judged in a hanging-drop preparation under a cover glass sealed by vaseline, or by means of repeated fresh-drop examination of the seminal fluid, which has been kept in a corked bottle at a temperature of from 8 to 20 degrees C. At 8 degrees C., motility has been observed for as long as 96 hours after ejaculation,[95] and often for 12 to 30 hours at room temperature. Despite considerable individual variation, diminution in vitality may be considered a criterion in the estimation of lessened fertility. Further study should be made along these lines.

A stained slide is then made in order to permit more minute examination with the oil immersion objective. A thin preparation of seminal fluid is allowed to dry on a glass slide, is fixed by heating, and then stained with 0.25 per cent. aqueous gentian violet solution for 30 seconds. This constitutes a permanent record.

Spermatozoa count. Although microscopic examination of a seminal-fluid drop gives a fairly good idea of the number, an actual count of the spermatozoa is believed by some to be a more accurate method. We have been employing the technic of Macomber and Sanders,[96] as modified by Belding.[97]

Technic. To 1 cc. of seminal fluid in a graduated cylinder, from 19 cc. to 99 cc. of a solution of 5 per cent. sodium bicarbonate and 1 per cent. formalin are added. We dissolve several drops of alcoholic gentian violet in this solution, in order to visualize the spermatozoa more distinctly. The dilution is varied from 1:20 to 1:100, according to the number of spermatozoa estimated at a preliminary microscopic examination of a wet seminal-fluid drop. A small amount of the diluted seminal fluid is then placed in a white-blood-counting chamber, the computation being made as in an ordinary blood count.

Normal variations. The average number of spermatozoa found in the seminal fluid of normal men is estimated at from 100 to 120 million spermatozoa per cubic centimeter,[6, 96, 97] although considerable variation normally occurs. For example, a presumably normal individual, repeatedly examined by Belding, varied between 51.4 million and 258 million in less than a month. Even more extreme ranges are sometimes found. This variation may be caused by such factors as the frequency of coitus, general health and nutrition, and mental status. It is, therefore, obviously necessary to make several spermatozoa counts in an individual before arriving at a definite conclusion. There is also a technical percentage of error in the dilution and the counting which is estimated at from 7.6 per cent. to 20 per cent. The spermatozoa count, multiplied by the volume of the seminal fluid, gives the total number of spermatozoa in one ejaculation, which is probably a more accurate index of fertility.

The least number of spermatozoa per cubic centimeter necessary for impregnation is unknown. It is generally considered that from 50 to 60 million per cubic centimeter are required.[6, 96] However, the author has seen an instance in which 45 million sufficed, and Macomber and Sanders[96] have reported impregnation with counts of less than 45 million.

Value of spermatozoa counts. Repeated spermatozoa counts may serve as a guide in the diagnosis, prognosis, and therapy of sterility. They furnish an index of the degree of sterility and provide a statistical means of following a case. However, in view of the wide normal variation and the large percentage of technical error, it is questionable whether the information obtained from spermatozoa counts justifies in routine cases the time and energy consumed in making them.

THE EXAMINATION OF THE MALE

History. A detailed general history should be elicited from every patient complaining of sterility. In addition, it is important to obtain certain specific information. The following history form is used routinely in the male sterility clinic of the Beth Israel Hospital, New York City.

1. Diet, especially in regard to vitamins, alcohol, drugs, and tobacco.
2. Endocrine disorders.
3. Congenital malformations, such as cryptorchidism, hypospadias, and epispadias.
4. Infectious diseases, such as gonorrhea, syphilis, mumps, orchitis, tuberculosis, typhoid, and pneumonia.
5. Operations, such as hernioplasty and testicular operations.
6. Injuries to genital organs and passages.
7. X-ray and radium exposure.
8. Genitourinary symptoms.
9. Coital history.
10. Familial history.

Physical examination. A thorough general physical examination must be made in every case of sterility. Particular attention should be paid to general nutrition, fat and hair distribution, and other signs of endocrine disorder. It is important to recognize the minor degrees of pituitary dysfunction. In such cases, roentgenograms of the sella turcica and long bones should be made. The sella turcica may appear normal, however, though marked pituitary disorder is present. Not infrequently, thyroid dysfunction may be associated with disorders of the pituitary. Sterility patients should often be investigated from the point of view of thyroid function by means of basal metabolic determinations. In certain endocrinopathies, hormonal tests may be of great value. The body weight and blood pressure are determined routinely.

Urological examination. Careful examination of the genital organs is obviously essential. In addition, microscopic studies are made of the prostatic secretion and of the separate secretions of the right and left seminal vesicles. The presence of leucocytes in the prostato-seminal-vesicular secretion, or in the seminal fluid, is an indication of inflammation in the prostate or seminiferous organs. Frequently, however, the number, motility, and vitality of the spermatozoa is unimpaired, despite prostato-vesicular inflammation, as evidenced by examples of impregnation not uncommonly occurring during the course of an acute gonorrhea.

An increased amount of amorphous debris and of crystals is not uncommonly observed in the seminal fluid in cases of oligospermia and necrospermia. The significance of this finding is not clearly understood. Perhaps it is the result of disintegration of the spermatozoa due to toxic agents or to prolonged retention in the seminiferous tract. In 3 cases of oligospermia and necrospermia, in which a considerable amount of debris and crystals was found, a spectacular improvement in the motility, vitality, and number of the spermatozoa was noted following prostato-vesicular massage. It is quite possible that plugs of debris and mucus, blocking the ejaculatory and prostatic ducts, are evacuated by vigorous massage.

Instrumental examinations, such as the passage of bougies, urethroscopy, and cystoscopy, are performed only when there are special indications for these procedures. Transurethral dilatation of the ejaculatory ducts is difficult, uncertain, and hazardous.

Laboratory tests. A complete urine analysis, a blood count and hemoglobin determination, and a blood Wassermann test should be done routinely in every case. In addition, a basal metabolism determination and x-rays of the sella turcica and long bones are often indicated. Sugar-tolerance tests are performed in cases of suspected hypophyseal deficiency.

THE EXAMINATION OF THE FEMALE

The female of every childless couple should be competently examined by a gynecologist. This examination may include such special tests as tubal insufflation (Rubin test), and endocrinological and hormonal studies. These more extensive examinations should be deferred until seminal-fluid studies have demonstrated that the husband is at least potentially fertile. Since, however, conception is the only successful result, it is obviously fruitless to treat the male partner unless the female appears capable of impregnation.

Antagonism of secretions. Occasionally, impregnation does not occur despite the fact that the seminal fluid appears adequate on repeated examination, that coitus is satisfactory, and that the female is found relatively normal. The assumption that there is an antagonism of the secretions is a tacit admission that a real understanding of this type of sterility is beyond our present knowledge. It has been demonstrated, however, that, in animals on a vitamin-E-free diet, a loss of the fertilizing power of the spermatozoa may occur before any marked diminution in number or motility is apparent. In like manner, minor degrees of endocrine disturbance, giving few or no clinical signs, may, nevertheless, account for a lessened fertility.

Post-coital examination (Hühner test). If the seminal fluid reveals that the spermatozoa are adequate in number, morphology, motility, and vitality, the next step is a post-coital study of secretions obtained from the vagina and the cervix uteri.[98, 99] This examination should be made preferably within an hour after coitus. A small amount of secretion is aspirated from the posterior cul-de-sac of the vagina, and another, separately, from the cervix. These secretions are placed on warm glass slides and examined microscopically.

Vaginal contents. Spermatozoa in contact with the acid vaginal secretion rapidly lose their motility. Therefore, examination of the post-coital vaginal contents cannot be regarded as a true indication of spermatozoal motility or vitality. It does reveal, however, the presence and morphology of the spermatozoa, as well as the approximate number delivered.

Cervical contents. Examination of the post-coital cervical contents is considered of greater importance. At the present time, the majority of investigators believe that, for the most part, only those spermatozoa which are directly injected into the cervix are capable of impregnation. In normal cases, from one to a dozen or more spermatozoa may be seen in a high-power field. A good many of these are actively motile.

Absence of spermatozoa indicates either faulty delivery of the seminal fluid, or a marked diminution in number, or, possibly, great antagonism of the cervical secretion. Lack of motility of the spermatozoa in the cervical contents indicates antagonism of the secretions, if such a condition really exists, or perhaps a diminution of spermatozoal motility and vitality.

Information obtained from the post-coital examination of the female supplements that obtained from the direct seminal-fluid studies. Post-coital examination cannot be regarded as a substitute for direct seminal-fluid study. It should be made after, and in addition to, the seminal-fluid examination.

DIFFERENTIAL DIAGNOSIS

For practical therapeutic purposes, sterility may be divided into two classes:

1. Non-obstructive sterility, a complete or partial deficiency in the manufacture of spermatozoa by the testes.

2. Obstructive sterility, a fault in transportation, due to a block in the seminiferous passages at any point from the rete testis to the urethral meatus.

A diagnosis of obstructive sterility may be made only with a constant finding of azoospermia in repeated seminal-fluid specimens. Obviously, the presence of a single spermatozoon in the seminal fluid proves the patency of the seminiferous ducts. Signs of chronic inflammation and thickening of the epididymes and the vasa deferentia are corroborative evidence of obstructive azoospermia. However, azoospermia may also be found in the absence of any obstructive lesion, as, for example, in cases of bilateral cryptorchidism, congenital maldevelopment, or severe atrophy of the testes. In such cases, the testes are often very small, or soft and flabby, or sometimes absent. In doubtful cases, further information may be obtained by testicular puncture, an unreliable method, or better, by operative exposure of the testes with biopsy. Vaso-seminal vesiculography, following the injection of iodized oil, either through a vasostomy or, rarely, through the ejaculatory ducts, has proved of great value in demonstrating the patency of the vasa deferentia and ejaculatory ducts.

THE TREATMENT OF STERILITY

The treatment of non-obstructive sterility is directed along etiological lines, an attempt being made to remedy the deficiencies and pathological lesions revealed by examination. Although non-obstructive sterility may often be due to a single cause, it is quite commonly the result of a number of factors. For this reason several indicated types of therapy may be simultaneously employed.

The treatment of obstructive sterility is designed to overcome the blockage, in order to insure free passage of the seminal fluid from the testes through the urethral meatus.

THE TREATMENT OF NON-OBSTRUCTIVE STERILITY

Nutrition. A well-balanced diet containing adequate amounts of food essentials should be routinely prescribed in all cases of sterility. Cod liver oil and other vitamin-rich concentrates may be added to the diet whenever necessary.

Vitamin E. Little is known regarding the value of vitamin E in the treatment of human male sterility, nor are there any reported observations concerning the effects of vitamin-E deficiency on the histology and function of the human testis. If changes do occur similar to those found in rats on vitamin-E-free diets, resulting eventually in degeneration and loss of the germinal epithelium, such lesions are, for the most part, irreparable. Only those cases, in which some germinal epithelium capable of function still remains, could be helped by the administration of vitamin E. The author's experience is too recent and limited to warrant any definite conclusions. It appears, however, from the dietary histories that very few of our sterility patients are potential sufferers of vitamin-E deficiency.

It seems at present that the important field for vitamin-E therapy lies in the prevention rather than in the cure of sterility.[13, 16] A properly balanced diet, containing lettuce and other green vegetables, corn oil, muscle meats, and whole wheat flour, should be adequate. The need for vitamin concentrates does not, in general, appear as urgent as some of their manufacturers would have us believe. The rate of involuntary childless marriage in the United States has been about 10 per cent. Most of these were due to inflammatory disease and to congenital and endocrinological abnormalities. The average diet in this country seems up to the present time to have contained sufficient vitamin E to have insured an ever-increasing population.

However, in cases of suspected vitamin-E deficiency, wheat germ oil, a rich source of vitamin E, may properly be added to the diet. We have observed no ill effects from its administration over fairly long periods of time.

In the occasional instances of so-called antagonism, in which impregnation does not occur despite the fact that the seminal fluid is adequate, that coitus is satisfactory, and that the female is found normal, the empiric administration of vitamin E may be worthy of a trial.

Anterior hypophysis. The symptoms of hyperpituitarism have at times been successfully arrested by radiotherapy and by surgical intervention. Whether such therapy will prevent the loss of gonadal function has not as yet been determined.

Hypophyseal gonadotropic hormones. The clinical use of extracts, containing the maturity principle of the anterior lobe, has not as yet been possible in cases of hypophyseal hypofunction. Such extracts at present are variable and impure, and those commercially available have not been sufficiently investigated to prove their potency or reliability. However, from experimental evidence in animals, the injection of the maturity principle of the hypophysis seems to offer great possibilities for the stimulation of spermatogenesis.

Pregnancy urine gonadotropic hormone (*prolan*). There are several potent and fairly reliable preparations of prolan commercially available. In recent years, many successful results have been reported following prolan injection in cases of cryptorchidism in fat boys (Fröhlich type).

In some cases of azoospermia,[30, 31, 32, 33] oligospermia, and necrospermia, the administration of prolan has been accompanied by an increase in the number and motility of the spermatozoa. The author has never seen a successful result in any established case of azoospermia. However, in 10 cases of oligospermia and necrospermia, a definite increase in the number and motility of the spermatozoa was observed following the injection of prolan. In 3 of these cases impregnation occurred. Several patients have noticed also an increase in libido and potency during the period of injection.

Because of our limited knowledge of endocrinological and hormonal therapy, the empiric administration of prolan may occasionally be justified in the hope of stimulating the germinal epithelium of testes compromised by, or operated on for, other lesions. Such treatment, however, should not be unduly prolonged. Although no ill effects have been observed by us following the administration of prolan in total doses up to 5000 rat units (300 to 450 rat units per week), the long-continued injection of pregnancy urine extracts may cause the formation of antihormones[28] or antibodies, and inhibit spermatogenesis. If, after trial prolan therapy (3000 to 5000 rat units), a case of non-obstructive azoospermia shows no improvement, treatment should be discontinued. The condition may well be regarded as hopeless, unless biopsy of the testis demonstrates germinal epithelium which appears capable of function.

On the other hand, oligospermia and necrospermia are incontrovertible evidence that some functioning germinal epithelium remains. These cases deserve painstaking therapeutic efforts. Great improvement in the seminal fluid, with subsequent impregnation, has occasionally occurred following prolonged and seemingly fruitless treatment.

Thyroid. Excellent clinical results have not uncommonly been seen in cases of sterility suffering from thyroid deficiency following the oral administration of thyroid extract. Sufficient quantity should be given to restore the pulse and basal metabolic rate to within normal limits.

Suprarenal cortical extracts. Suprarenal cortical extracts (eschatin, cortin) are as yet of questionable potency.[100] Until such time as the relationship of the suprarenal glands to spermatogenesis is more clearly understood, and an extract of known potency has been used experimentally in a large series of cases, suprarenal hormonal therapy in cases of sterility appears contraindicated.

Testis. *Male sex hormone.* The therapeutic value of male sex hormone is highly problematical. The preparations, commercially available at the present time, are uncertain as to potency and purity. Isolated cases of hypogonadism treated by the injection of male sex hormone have shown little or no change in the genitalia or secondary sexual characteristics. However, an increase in erection and, occasionally, in ejaculations, has been observed.

The male sex hormone does not stimulate the gonads or their spermatogenic function,[48, 101] but, on the contrary, in young rats it has been shown to injure the testicular tissue.[102, 103] In addition, there is evidence that it acts as an inhibitor on the gonad-stimulating action of the anterior hypophysis. For these reasons, male sex hormone is contraindicated in the treatment of sterility.

Pancreas. Adequate treatment of diabetics is obviously indicated.

Faulty delivery. *Impotence.* Temporary impotence is generally relieved by sexual rest, reassurance, and the elimination of faulty sexual habits. Congestion of the posterior urethra and inflammatory swelling of the verumontanum not infrequently result from abnormal sexual practices. These lesions may require local treatment, such as the instillation of astringents or topical applications through the urethroscope. The verumontanum may also be fulgurated with bipolar current through the shock-proof urethroscope.[104]

The majority of cases of impotence in younger men are due to psychological causes and should properly be referred to the psychotherapists. Plastic operations may sometimes be indicated. Lowsley[105] has reported good results in cases of impotence due to traumatic or inflammatory lesions of the perineum, lack of muscle tone, and other organic factors. These cases must be skilfully selected and handled, however, and he cautions against the indiscriminate use of operative procedures in the treatment of impotence.

Lesions of the urethra. Hypospadias and epispadias which interfere with the proper ejaculation of the seminal fluid, should be corrected surgically. Strictures of the urethra require dilatation to sufficient caliber to permit unimpeded seminal-fluid ejaculation.

Undescended testes. *Hormonal therapy.* In recent years, many instances of testicular descent have been reported following the injection of prolan.[106, 107, 108, 109, 110, 111, 112] The most favorable results have been observed in boys of the Fröhlich type. On the other hand, prolan therapy, administered after puberty, offers little or no chance of testicular descent. Three adults, so treated by the author, showed no improvement. It is agreed that hormonal therapy in cryptorchidism should be instituted before the onset of puberty. Large doses (3000 to 5000 rat units) may be required before descent takes place.

Operative therapy. If complete descent has not occurred, as is quite often the case, following adequate prolan therapy an operative attempt should be made to bring the testis into the scrotum. This should be done not only to promote spermatogenesis, but also in order to lessen the chance of malignant neoplasm and tortion.[77, 113] A variety of operative procedures have been described. Simple orchidopexy and the Torek operation are today most generally employed. A detailed discussion and description of these operations may be found in *The Oxford Surgery*, Volume 4, page 38.

Following operation, the administration of prolan has been recommended, in order to stimulate the development of the interstitial tissues and, possibly, of the germinal epithelium.

The question of the restoration of the spermatogenic function of undescended testes after puberty has recently been reopened by the work of Pace and Cabot.[114] They have reported the results of histological examination of 24 undescended testes, removed surgically after puberty. A considerable number of the specimens, removed in the second, third, fourth, and fifth decades, showed germinal epithelium which the authors felt might have developed normally. Testes removed in the sixth and seventh decades showed complete fibrosis and degeneration.

In like manner, biopsy of an undescended testis, performed by the author during the course of an orchidopexy in a 23-year-old man, showed areas of relatively normal germinal epithelium with abortive attempts at spermatogenesis. These findings suggest the necessity for further histological studies of undescended testes in adults. Seminal-fluid examinations should be made pre-operatively and post-operatively in all cases of cryptorchidism, in order to determine the value of orchidopexy for the relief of sterility.

Syphilis. Good results have been reported in testicular syphilis, following the administration of anti-luetic treatment. If, however, the disease is advanced or of long duration, the germinal epithelium may well be irreparably damaged.

Varicocele. A porous suspensory should first be tried in the treatment of varicocele. The suspensory should be made of thin, loose mesh cloth, in order to avoid insulation with a resultant increase in scrotal temperature. If, after several months' trial, the seminal fluid does not improve, operative correction of the varicocele is indicated, provided that the testis is not completely atrophied. Operation is also indicated if the wearing of a suspensory has resulted in only slight improvement in spermatogenesis.

The author has operated for varicocele in 3 cases of marked oligospermia and necrospermia. One of these showed 60 million actively motile, normal spermatozoa per cubic centimeter 6 months later. Impregnation occurred. Another patient was unable to impregnate his wife, despite an appreciable increase in the number and motility of the spermatozoa. The third patient was unimproved. A well-balanced high vitamin diet had been prescribed for these patients, and, in addition, prolan had been administered pre-operatively without appreciable benefit. Prolan injections were also given post-operatively in order to stimulate the germinal epithelium of the operated testis.

Macomber and Sanders[96] have likewise reported a case of bilateral varicocele in a patient suffering from sterility. He was operated on with an excellent result.

It seems reasonable to hope that the operative correction of varicocele in some cases of sterility may improve the spermatogenic function, or, at least, may prevent further deterioration of the germinal epithelium.

X-ray and radium. The question as to whether small doses of x-ray or radium may exert a stimulating effect on the germinal epithelium is an interesting one. Pais[115] has reported the finding of spermatozoa in the seminal fluid of patients previously sterile, following exposure to minimal doses of radium. Hühner,[116] on the other hand, has concluded that small doses of x-ray, ordinarily considered harmless, may cause sterility.

Testicular atrophy. Azoospermia due to testicular hypoplasia or atrophy is usually permanent. The only hope lies in the prevention of complete degeneration of the germinal epithelium. If the spermatogenic tissue has been spared to some extent, the elimination and correction of the causative factors discussed above may result in a considerable degree of recovery.

THE TREATMENT OF OBSTRUCTIVE STERILITY

The treatment of obstructive sterility is surgical, an attempt being made to relieve the blockage by anastomotic operation. A diagnosis of obstructive sterility can be made only in the continued presence of azoospermia. A single spermatozoon in the seminal fluid obviously proves patency of the ducts. It is important, also, to be sure that the azoospermia is not due to loss or degeneration of the germinal epithelium, as is seen in cryptorchidism, atrophy, or congenital underdevelopment. (See **Differential Diagnosis,** page 746 (298–29A).) A history of bilateral epididymitis, usually gonorrheal, combined with the finding of thickened nodular epididymes and normal testes, is additional evidence that the cause of the azoospermia is obstructive.

Criteria for anastomotic operations. The following conditions must be satisfied before any operation for the reestablishment of the seminiferous pathways is attempted:

1. The vas deferens and the ejaculatory duct are patent from the point of intended anastomosis into the urethra.
2. The testis contains and is capable of producing spermatozoa.
3. There are no acute or subacute inflammatory lesions in the genital organs or passages.

Patency of the seminiferous pathways. Patency of the vas deferens and ejaculatory duct may be established by the injection of a colored fluid into the vas deferens at the point of intended anastomosis and by its subsequent recovery from the urethra. This is a reliable method. On the other hand, probing of the vas deferens with a wire stylet or with silkworm gut is unsatisfactory, since it does not prove the patency of the abdominal vas deferens or ejaculatory duct. In addition, a wire stylet may seriously traumatize or perforate the vas deferens. It also seems reasonable that a partial obstruction, permitting the passage of a thin colored solution, might, nevertheless, impede the thicker spermatic fluid. Moreover, it is not always sufficient to establish the patency of the seminiferous pathways, since unrecognized non-obstructive inflammatory lesions may seriously militate against the success of an anastomotic operation. For these reasons, the author believes that roentgenographic visualization of the seminiferous pathways should be routinely employed before attempting any such operation.[117] Vaso-seminal vesiculography not only proves the patency of the vas deferens and ejaculatory duct, but also graphically demonstrates non-obstructive lesions in the seminal vesicles and the seminiferous tract.

Vaso-seminal vesiculography. The vasa deferentia, seminal vesicles, and ejaculatory ducts may be visualized roentgenologically either by catheterization and injection of radio-opaque fluid into the ejaculatory ducts, or by injection into the vas deferens through a scrotal vasotomy.[118, 119]

(1) Catheterization of the ejaculatory ducts. Although Klotz[120] in 1895 was the first to catheterize and inject the ejaculatory ducts through a urethroscope, it was the work of Luys,[121, 122] and Young and Waters[123] which aroused general interest in this method. The two latter had devised a new instrument and catheter through which they were able to make several seminal vesiculograms by the injection of thorium nitrate solution. Waters said that "it is easy once the ducts are located. How-

ever, this requires tedious and persistent search." Somewhat later, an improved instrument was presented by Lowsley and Delzell,[124] who wrote that "it is possible to inject a rather high percentage of seminal vesicles through the ejaculatory ducts." More recently, Le Fur[125] reported that he had succeeded in catheterizing the ejaculatory ducts in 80 per cent. of his cases. However, no seminal vesiculograms were made. Lavage of the seminal vesicles was not infrequently followed by epididymitis. More modern instruments have been devised by von Lichtenberg and Heynemann,[126] MacCarthy,[127] and by Lowsley and Peterson.[128] Peterson showed a number of seminal vesiculograms.

On the other hand, François[129] succeeded in making seminal vesiculograms but twice in 14 attempts at ejaculatory-duct catheterization. Rolnick[130] also has pointed out the difficulties encountered in ejaculatory-duct catheterization. He stated that most attempts have failed because the orifices could not be seen due to their anatomical location. In addition, the catheter not infrequently meets an impassable obstruction within the duct. In the occasional case in which the ejaculatory duct has been successfully catheterized, the injected fluid usually flows into the seminal vesicle and not into the ampulla and vas deferens.[121, 130, 132, 133] These findings were confirmed by cadaver experiments. In 58 attempts, Rolnick was only 8 times able to inject fluid beyond the seminal vesicle into the ampulla of the vas deferens.

From these observations and from the experience of many other urologists,[118, 129, 131, 134] it may be concluded that catheterization and injection of the ejaculatory ducts is a very difficult and uncertain procedure. Vaso-seminal vesiculograms, made by this method, are indeed few. The author has found that the orifices of the ejaculatory ducts frequently could not be seen because of edema and inflammation of the urethral mucosa and of the verumontanum. The urethroscopic field was quite commonly obscured by blood, pus, and fibrin. In the occasional cases in which the orifices were seen, the ducts could often not be catheterized, the catheter or cannula tearing through the verumontanum or the urethral mucosa. Such instrumental manipulations are not rarely followed by epididymitis. It appears that vaso-seminal vesiculography by means of ejaculatory-duct catheterization is too hazardous for routine use in the diagnosis and treatment of sterility, and is quite apt to fail in the hands of skilled urologists.

(2) Scrotal vasotomy. Vaso-seminal vesiculography by means of scrotal vasotomy is technically simple, relatively harmless, and usually successful. The author and his co-workers were able to make 65 satisfactory seminal vesiculograms in 69 attempts. There were no untoward effects.

Technic. Under local novocaine anesthesia, the vas deferens is isolated through a small scrotal skin incision. The sheath of the vas deferens is then split longitudinally and partially dissected from the vas deferens for a distance of about 1 cm. Care should be taken not to divide the sheath or its blood vessels completely. The vas deferens is held taut by 2 guy sutures, and a tiny longitudinal incision is made into its lumen. A blunt Luer needle (gauge 20) is gently inserted through this incision into the lumen, and from 1 to 3 cc. of warm iodized oil is slowly injected. The oil should flow in without undue pressure. Resistance to the flow indicates either an obstruction in the seminiferous passages, or a false injection outside the lumen into the perideferential tissues. If the latter occurs, a second injection should be attempted in a somewhat more distal portion of the vas deferens. After the injection has been made, the needle is withdrawn. No sutures are required, the incision in the vas deferens being closed by firm pressure between the thumb and index finger for several minutes. The spermatic cord is then replaced into the scrotum and the skin wound closed by interrupted plain catgut sutures. A small collodion dressing is applied.

Roentgenograms are made immediately, or within a few hours, although occasionally excellent vaso-seminal vesiculograms have been obtained several days after injection (Fig. 6). Thin iodized oil is much more satisfactory than protargol, argyrol, sodium iodide solution, or skiodan. The iodized oil is non-irritating and, adhering better to the lining of the seminiferous passages, gives sharper x-ray visualization. In 3 cases the author has examined histologically the seminal vesicles and portions of the vas deferens into which iodized oil had been injected from 13 to 31 days previously. In no case was there any evidence of irritation or inflammation. We have also observed in animals and at autopsy in man that small longitudinal wounds in the vas deferens heal without occlusion of its lumen. It is frequently impossible to identify grossly the site of incision. The experimental results of Rolnick agree with our clinical observations.[135]

Vaso-seminal vesiculography not only gives reliable graphic evidence of the patency of the seminiferous passages, but may also demonstrate the presence of pathological lesions. Unsuspected abscess or cyst of the seminal vesicle has several times been found (Figs. 1 and 7). Iodized oil, when retained in occluded seminiferous passages or when extravasated into the tissues, may be very gradually absorbed. On the other hand, it may remain *in situ* for many months without any symptoms or harmful effects. Vaso-seminal vesiculography should be done in every case of obstructive sterility before any anastomotic operation is attempted.

The spermatogenic capacity of the testis. Moore and Oslund[65] have demonstrated in animals that, following ligation of the vas deferens, the testis is able to produce living spermatozoa for a considerable time. In like manner, in cases of chronic obstructive epididymitis, the spermatogenic ability of the human testis has been amply proved by histological examination, by epididymal incision, and by the finding of normal motile spermatozoa in the ejaculated seminal fluid following anastomotic operation.

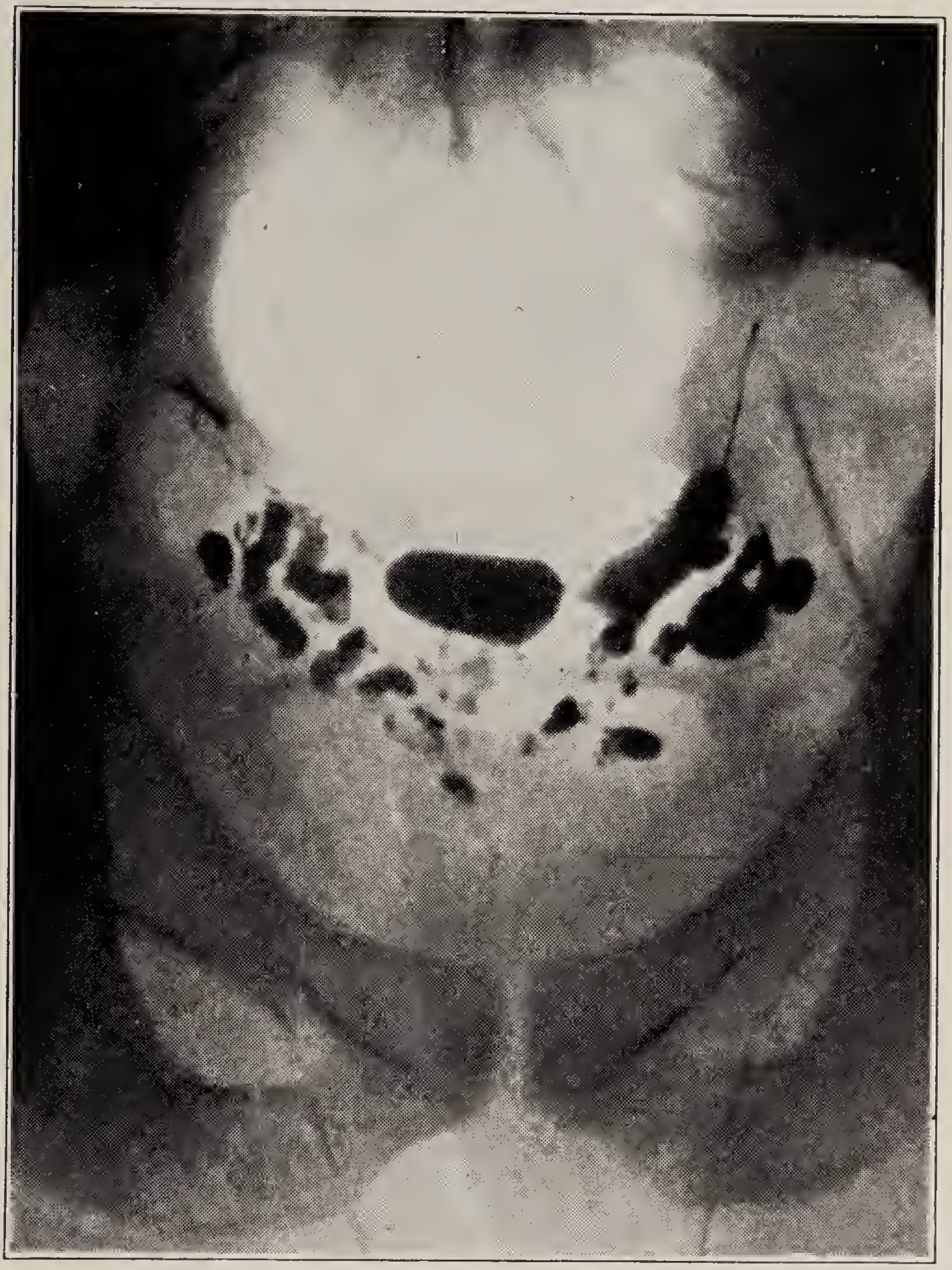

FIG. 6. A vaso-seminal vesiculogram demonstrating the patency of both vasa deferentia. The seminal vesicles are normal. Note the iodized oil in the bladder. Courtesy, Archives of Surgery.

(1) Testicular puncture. Following aspiration of the testes of presumably normal fertile men, Hühner[136] discovered spermatozoa in 56 per cent. of his cases, and Posner[137, 138] in 59 per cent. The latter concluded that a negative result was of little or no value. Somewhat later, Mühsam,[139]

puncturing the testes of cadavers, observed that a small piece of testicular tissue was not infrequently avulsed by the aspirating needle. Although spermatozoa were not always found, Mühsam was often able to identify single cells and groups of cells as spermatogonia or spermatocytes. He decided that testicular puncture gave reliable information concerning the spermatogenic capacity of the testis. In living patients, however, the avulsion of testicular tissue by an aspirating needle is obviously not

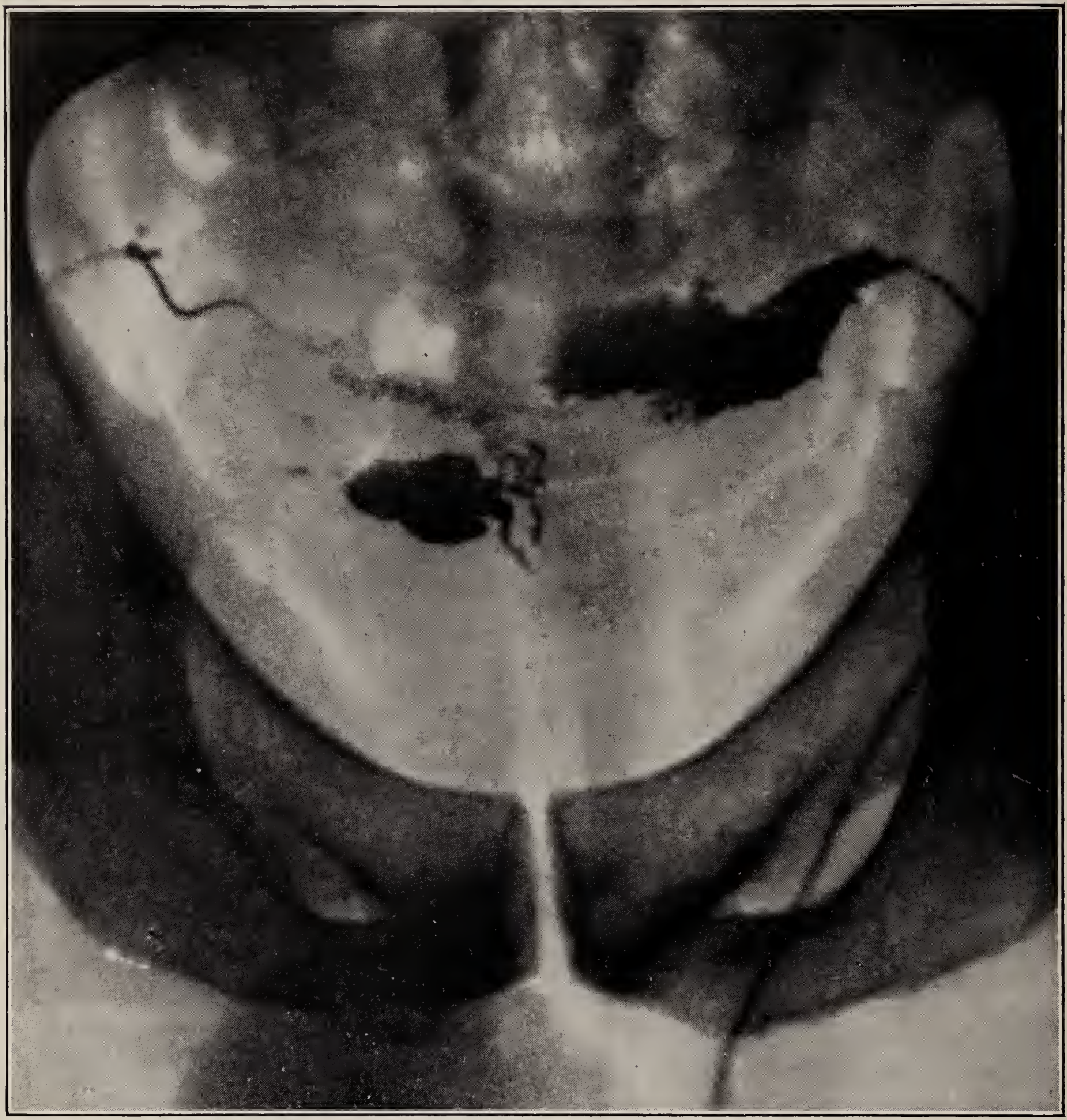

FIG. 7. Vaso-seminal vesiculogram in a case of obstructive sterility due to bilateral gonorrheal epididymitis. The right side is normal. Note the cyst-like dilatation of the left seminal vesicle with ejaculatory-duct occlusion.

without danger. Severe hemorrhage or infection may result in total loss of the testis.

Spermatozoa were found by D. L. Cohen and the author in the aspirated testicular fluid of 20 adult rabbits without exception. On the other hand, of 12 presumably normal fertile men whom we examined only 2 revealed spermatozoa on testicular puncture. These observations corroborate the general opinion that a negative finding is not uncommon and does not necessarily indicate a lack of spermatogenic ability.

(2) Epididymal puncture and incision. Fluid obtained by aspiration of the epididymis is often mixed with blood, making the identification of spermatozoa difficult, if not impossible. On the other hand, the examination of fluid expressed from an incision into the epididymis is a more reliable method. If spermatozoa are found, the anastomosis is made, joining the vas deferens to the margins of the epididymal incision (See *Vaso-epididymostomy*, pages 746 (298–42A), 746 (298–44A). In the event of a negative findng, a second and possibly a third incision should be made into other portions of the epididymis.

It has been more or less generally agreed that spermatozoa must be demonstrated in the epididymis or testis before proceeding with any anastomotic operation for the reestablishment of the seminiferous pathways.[140] However, in view of the high percentage of error in our tests of spermatogenic capacity, the author believes that a negative finding should not necessarily contraindicate the completion of an anastomotic operation, provided that the testis appears normal and that the vas deferens and ejaculatory duct are patent. The adoption of this dictum may increase the actual number of cures, although the percentage of successful results may be diminished.

(3) Biopsy. Histological examination of a biopsy specimen gives an accurate picture of the status of the germinal epithelium. Its use, however, is limited by the increased risk to the testis incident to surgical incision.

Inflammatory lesions. The presence of acute or subacute inflammatory lesions in the genitourinary tract is an absolute contraindication to any anastomotic operation for sterility. A complete urological examination, including microscopical studies of the urethral, prostatic, and seminal-vesicular secretions, should always be made. Cysto-urethroscopy should also be done when indicated.

Prostatitis and seminal vesiculitis require appropriate treatment, such as massage, local heat, and possibly the administration of a vaccine. It must be emphasized, however, that bilateral epididymitis does not always result in azoospermia.[88, 141, 142] Indeed, unimpaired fertility has not uncommonly been observed following bilateral gonorrheal epididymitis. It is, therefore, advisable to wait for at least a year after all the symptoms and signs of acute inflammation have subsided before attempting an operation for the reestablishment of the seminiferous pathways.

Tuberculosis of the seminiferous tract absolutely contraindicates anastomotic operation.

Operations for obstructive sterility. The first recorded surgical attempt to reestablish the seminiferous pathways was that of Bardenheuer[143] who in 1886, following epididymectomy for tuberculosis, implanted the cut distal end of the vas deferens in the testis. A large number of operations for the relief of obstructive sterility have since then been devised. These may be divided into five main classes:

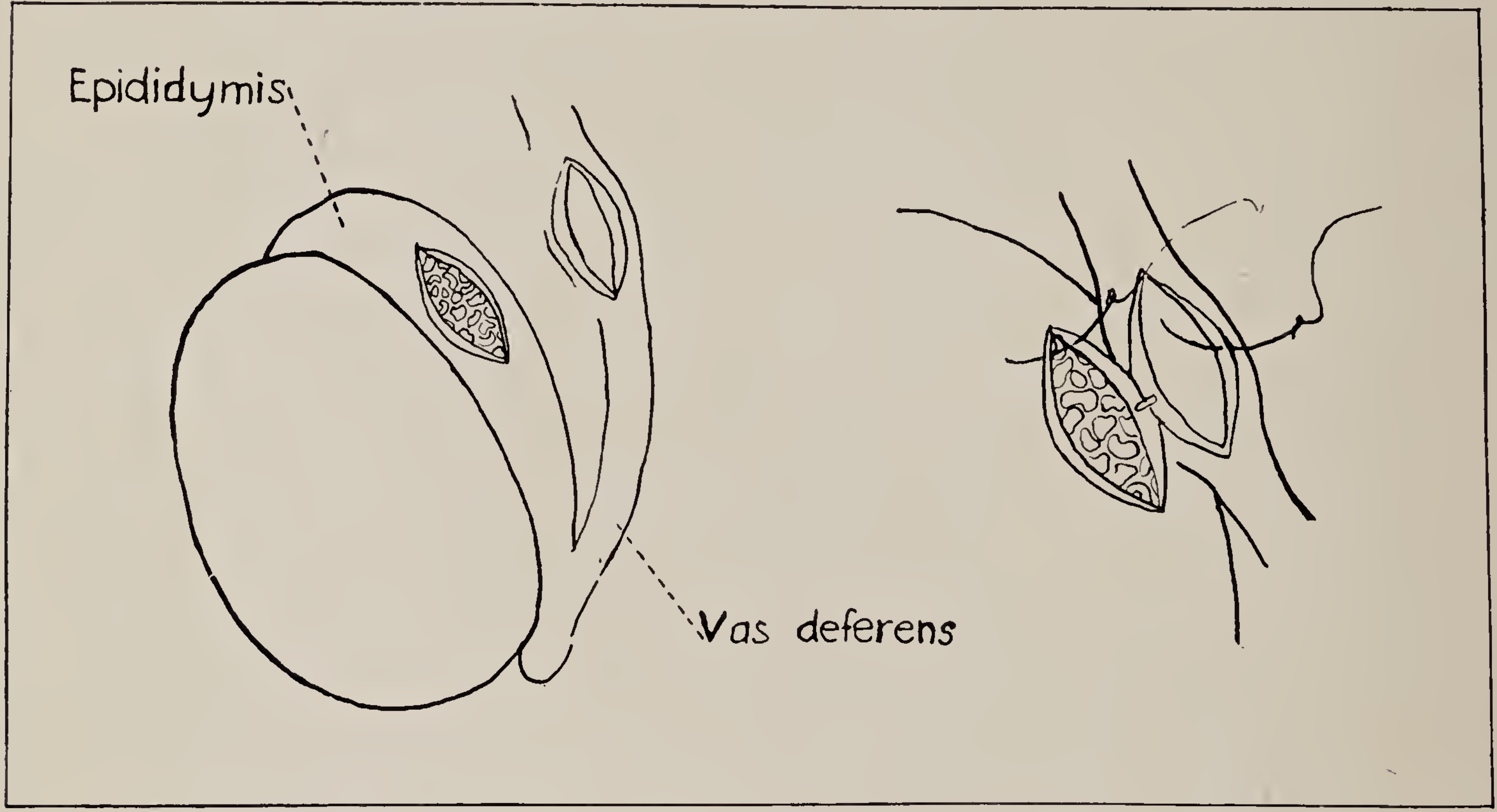

FIG. 8. A diagram illustrating the steps of vaso-epididymostomy.

1. Vaso-epididymostomy[144, 145, 146, 147, 148, 149, 150, 151]
2. Vaso-orchidostomy[143, 152, 153, 154, 155, 169]
3. Vaso-orchidostomy and vaso-epididymostomy with interposed spermatocele[117]
4. Vaso-orchidocystostomy[156, 157]
5. Miscellaneous operations
   - *a.* Sac epididymostomy[158, 159, 160]
   - *b.* Transplantation of the saphenous vein as a substitute for the vas deferens[161]
   - *c.* Vaso-urethrostomy[162]

Vaso-epididymostomy. From a review of the literature, it appears that Martin's vaso-epididymostomy with technical modifications is the most popular and the most successful operation for the reestablishment of the seminiferous pathways following obstructive bilateral epididymitis. The largest series has been reported by Hagner,[140] who achieved successful results in 21 of 33 operated cases, or 63.6 per cent. Martin[145] has reported 6 cures in 11 operations, and J. S. Read[5] 5 successes in 9 attempts. Moran[163] recovered spermatozoa post-operatively in 2 of his 4 patients, and, surprisingly, Bernart[164] was able to report successful results in 8 consecutive cases.

Despite these reports of operative cures in the hands of a few, the opinion of surgeons in general is rather pessimistic as to the end results of vaso-epididymostomy. For example, Caspar[142] was unable to recover spermatozoa in 3 operated cases. Goldstein[165] failed in 6 out of 7 cases, and McKenna[151] in 3 out of 5. Fürbringer, Stutzin, A. Hyman, and many others[141, 154, 155, 157, 166, 167, 168] are unenthusiastic as to the chance of success of this operation. There are undoubtedly a large number of unreported failures.

The reasons for failure of vaso-epididymostomy have been well summarized by Rolnick[153] as follows:

1. Vaso-epididymostomy is not a direct anastomosis.
2. Slight hemorrhage with a blood clot, trauma, and irritation, can produce enough scar tissue to occlude the anastomotic channel.
3. The epididymal tubule is very thin, and as friable as tissue paper.
4. The testicle moves up and down.
5. The new anastomotic channel may become gradually occluded by contraction of scar tissue.

For a detailed description and illustrations of the technic of vaso-epididymostomy, see *Oxford Surgery*, Vol. 3, 746 (466–472), and Fig. 8.

Direct anastomosis. Because the overgrowth of connective tissue and the organization of blood clots, occluding the epididymal tubules, had been recognized as likely causes of failure in vaso-epididymostomy, Lespinasse[150] attempted to perform a more direct anastomosis. He brought the epithelium of the vas deferens in close apposition to the epithelial lining of the epididymal tubule, depending on necrosis of a single tubule, following the tying of a crown stitch. Ten of 11 operated dogs and 1 patient passed spermatozoa in the seminal fluid post-operatively. It seems logical, however, that there will be a better chance for sinus formation between the epididymis and vas deferens if many tubules, instead of one, are cut across.[148] There have been no further reports of this operation since the original article was published.

Vaso-orchidostomy. Direct implantation of the vas deferens into the testis has been notorious for its failure.[146, 154, 155, 157] It is probable that there has never been a successful result following vaso-orchidostomy in man.[170] This operation seems almost certain to fail on anatomical and physiological grounds and should, therefore, be abandoned.

A modification of vaso-orchidostomy, in which a silkworm gut suture is passed through the rete testis in order to help the formation of a sinus, has been described by Rolnick.[153] No clinical results, however, have been reported.

Spermatocele. Bogoljuboff,[146] publishing the results of 24 vaso-epididymostomies in animals, frequently found, at autopsy, that a small intermediate cavity had formed between the vas deferens and the epididymis. These cavities were lined with cuboidal epithelium and in more than half the cases communicated directly with the tubules of the epididymis. They frequently contained spermatozoa and were, in reality, spermatoceles. It has also been clinically observed that the presence of a spermatocele enhances greatly the likelihood of success of anastomotic operations.

The artificial creation of a spermatic sac, or spermatocele, of vein, skin, or bladder mucosa, was first suggested by Lespinasse[158] in 1914. It was intended to tap this newly formed spermatic reservoir periodically for the purpose of artificial insemination in cases of pelvic vas deferens occlusion. The feasibility of implanting a patent distal vas deferens into such an artificially created spermatocele was evidently not considered. The author has been unable to find any published report that the procedure suggested was ever carried out in animals or in man.

More recently, Rolnick has attempted to create spermatoceles by partial and complete ligation of the epididymis of dogs.[171] He failed to produce a single spermatocele in 28 attempts. In the meantime, Hagner[140] reported that he had implanted the distal vas deferens into a spermatocele accidentally found at operation, and had recovered living spermatozoa in the ejaculated seminal fluid 6 weeks post-operatively.

Vaso-orchidostomy and vaso-epididymostomy with interposed spermatocele. The principles on which this operation[117] is based are as follows:

1. The entire spermatogenic tissue is used.
2. The testis is not traumatized.
3. The site of the anastomosis is completely epithelial in order that a minimal amount of scar tissue be formed.
4. A funnel-shaped sac, an artificial spermatocele lined with skin epithelium, is created, in order to join the larger cut open ends of the epididymal tubule or of the efferent ducts of the rete testis to the smaller lumen of the vas deferens.

This operation is performed in 2 stages. At the first stage, a perma-

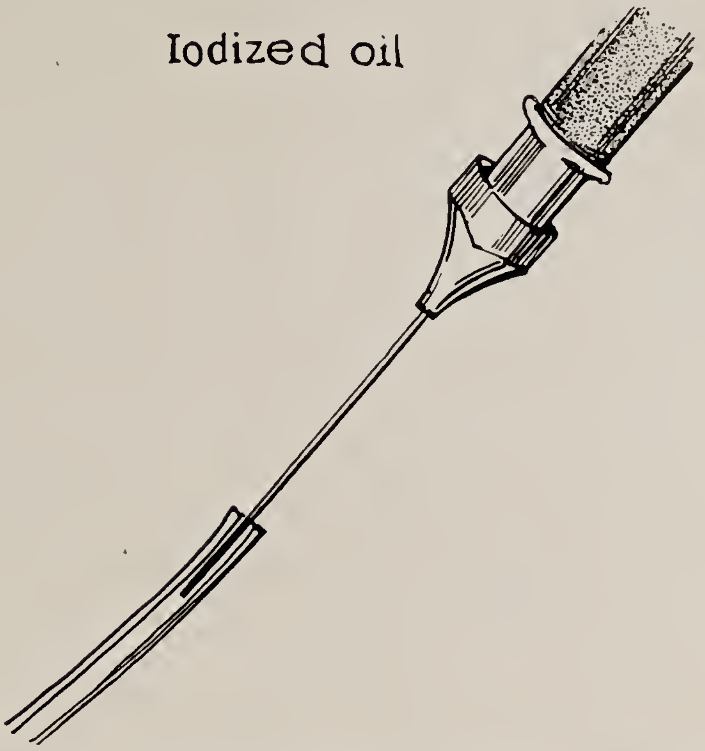

Fig. 9. A step in the first stage, showing a blunt needle inserted into the vas deferens for the injection of iodized oil for seminal vesiculography. Courtesy, Archives of Surgery.

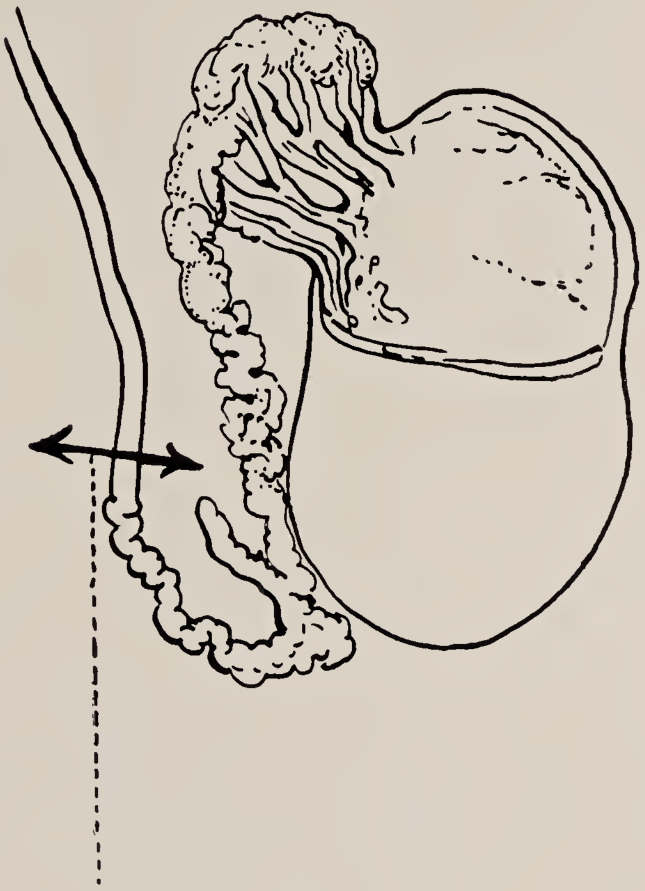

Fig. 10. The first stage in the operation, permanent vasostomy, in which the vas deferens is cut. Courtesy, Archives of Surgery.

nent vasostomy is made. When this is well healed, the second stage, vaso-sac orchidostomy or epididymostomy, is performed. The time interval required between the 2 stages is usually about 3 weeks.

Technic. First stage: permanent vasostomy. — Under local anesthesia, the vas deferens is isolated through a small skin incision made high in the scrotum. A small longitudinal incision is made into the lumen of the vas deferens, at a point just above the epididymis. A blunt needle is inserted into the lumen, and a vaso-seminal vesiculogram is made (See page 746 (298–36A) and Figs. 6 and 9). The vas deferens is then implanted into the scrotal skin wound, a strand of silkworm gut being left in the lumen in order to maintain its patency. The scrotal skin is loosely sutured about the implanted vas deferens, leaving a small raw area. This raw area allows a cuff of new *hairless epithelium* to grow inward from the scrotal wound edges to the vasostomy opening (Figs. 10 and 11).

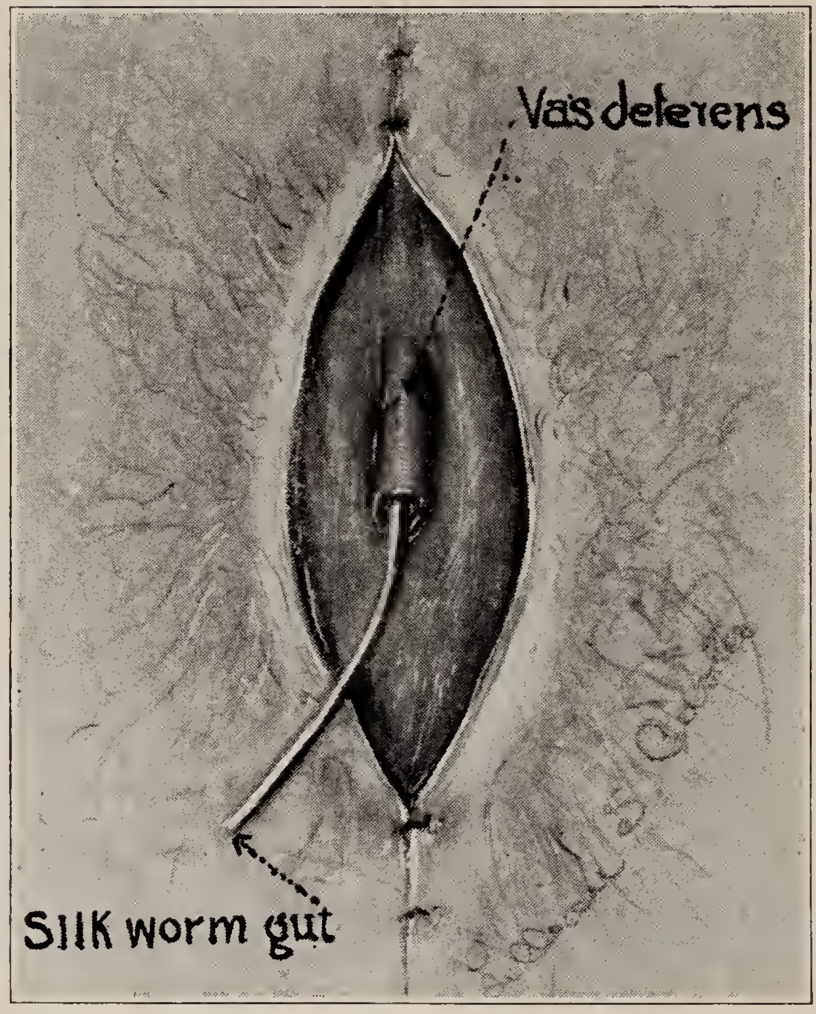

FIG. 11. The first stage completed. Note that the skin is loosely sutured about the vasostomy opening, leaving a raw surface for epithelization. Scrotal hair, though shaved at the time of the operation, has been diagrammatically inserted. Courtesy, Archives of Surgery.

Second stage: vaso-sac orchidostomy or epididymostomy. — The testis and epididymis are exposed through a low scrotal incision. The epididymis is then incised and the expressed fluid examined for spermatozoa. If spermatozoa are found, the anastomosis can be made to the margins of the epididymal incision. If, on the other hand, no spermatozoa are recovered from any part of the epididymis, the testis is aspirated as a matter of scientific interest. Regardless of the result of testicular aspiration, an epididymectomy is then performed, cutting transversely across the efferent ducts of the rete testis, leaving them gaping (Fig. 13a). Bleeding is carefully controlled by digital pressure and the application of epinephrine. Ligatures should be avoided whenever possible.

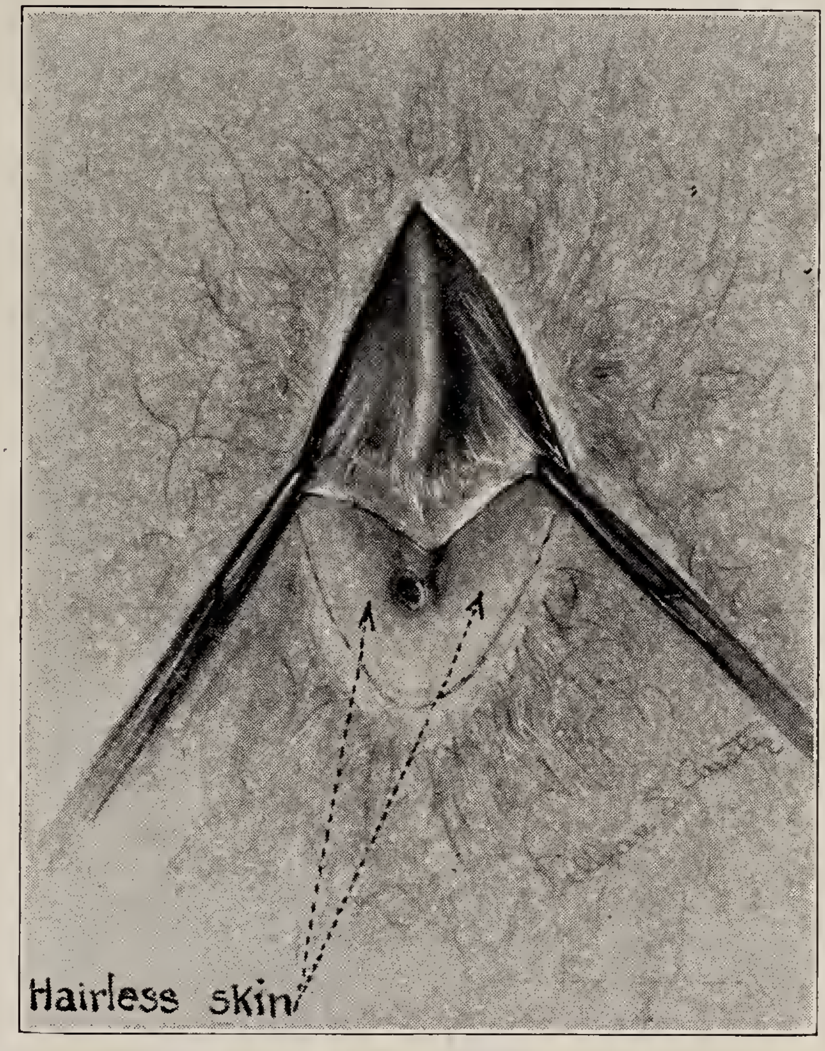

Fig. 12. The second stage in the operation, vaso-sac orchidostomy or vaso-sac epididymostomy. The vas deferens is freed with an attached cuff of new hairless skin. Courtesy, Archives of Surgery.

The vas deferens is now freed with a cuff of new *hairless skin* attached around the vasostomy opening (Fig. 12). The edges of the cutaneous cuff are sutured to the incised margins of the epididymis, or, in the event of epididymectomy, to the tunica albuginea around, but at a distance from, the cut efferent ducts of the rete testis. Fine interrupted chromic catgut sutures, or, better, silver-wire sutures, are used. An umbrella-like spermatic sac has thus been formed (Figs. 13 and 14). The scrotal skin incision is approximated by interrupted plain catgut sutures. No drains are used.

Discussion. A preliminary vasostomy is performed, in order that the opening in the vas deferens be patent and firmly healed to the surrounding skin before the major second stage is attempted. This tends to eliminate the chance of late stricture formation with occlusion of the vas deferens at the site of the anastomosis, a frequent cause of failure of these operations.[153] If the preliminary vasostomy opening should close for any reason, a second opening can easily be made in a more distal portion.

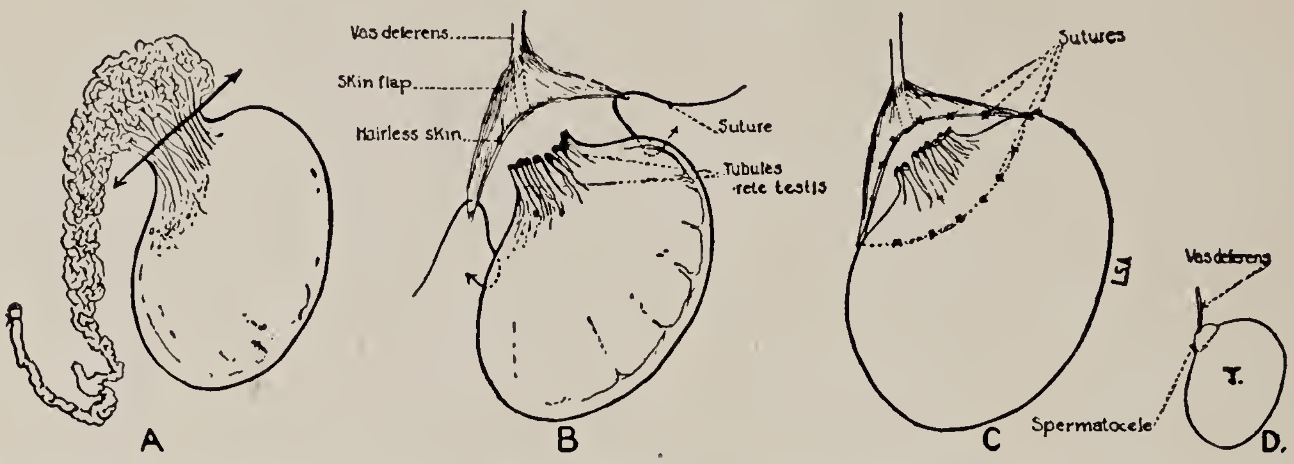

FIG. 13. A diagram of the steps in the vaso-sac orchidostomy. *A* indicates the stage at which the epididymis is cut, *B* and *C*, the skin flap with end sutures, and *D*, the external view of the completed operation. Courtesy, Archives of Surgery.

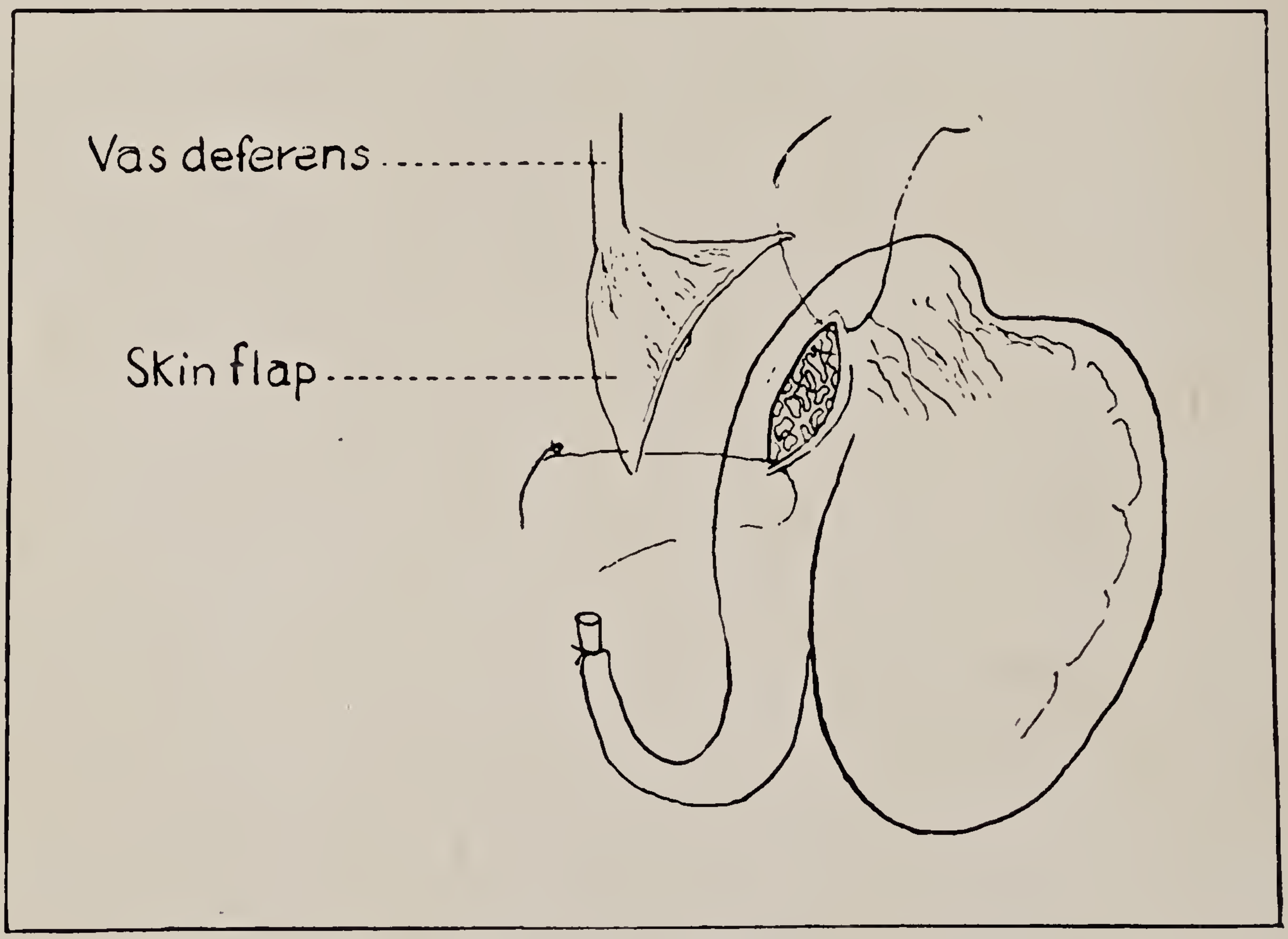

FIG. 14. A diagram illustrating vaso-sac epididymostomy.

The umbrella-like cuff of new *hairless skin* epithelium about the vasostomy (Figs. 13 and 14) enables the surgeon to place the anchoring sutures at some distance from the actual site of the anastomosis. There is, consequently, no foreign-body irritation or inflammation near the openings of the epididymal tubule or the efferent ducts of the rete testis. This tends to eliminate another frequent cause of failure of vaso-epididymostomy, i.e. inflammation and necrosis about the suture line with later scar contracture. It would appear that these advantages of vaso-epididymostomy with interposed spermatocele, and also vaso-orchidostomy with interposed spermatocele, would lessen the chance of failure in the operative treatment of obstructive sterility.

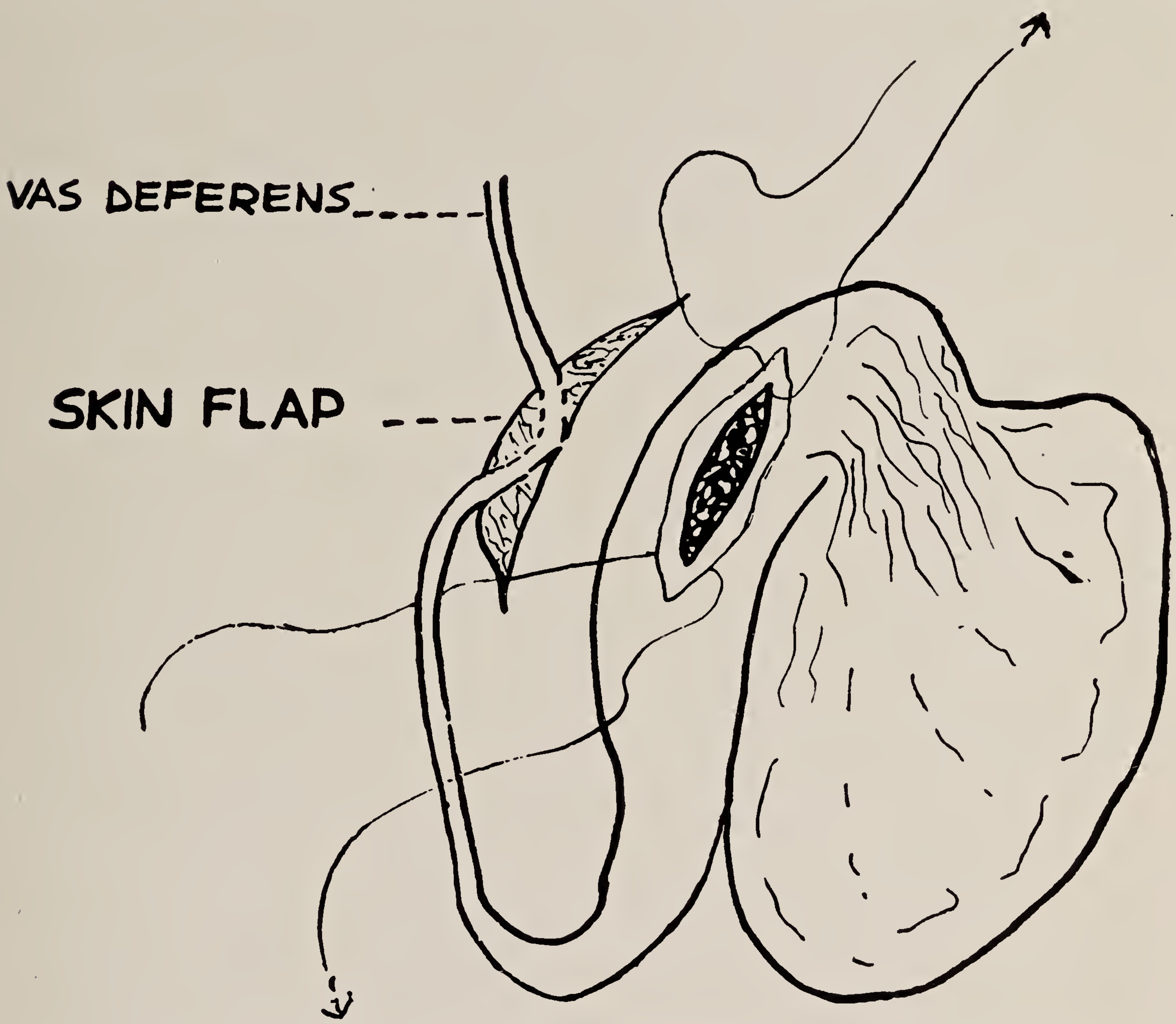

Fig. 15. A diagram illustrating a recent modification of vaso-sac epididymostomy. A lateral anastomosis is made. Note that the vas deferens remains attached to the epididymis.

Vaso-orchidocystostomy. In 1925 Gara[156] reported the successful experimental production of testicular cysts or spermatoceles. Following excision of a wedge of testicular tissue, normal saline solution was injected under pressure in order to produce a local anemia, and to prevent the walls of the testicular wound from collapsing. Subsequently, an operation was devised for the relief of obstructive sterility. The cut distal end of the vas deferens was freely implanted into such an artificially created defect in the testis. It was hoped that a spermatocele would form. Lichtenstern and Gara[157] reported 10 operated cases, in 3 of which spermatozoa were recovered post-operatively in the seminal fluid. There have been no subsequent reports of this operation.

The artificial creation of spermatoceles or spermatic cysts by this method must surely be inconstant. Trauma to the testis, hemorrhage, and late scar formation will account for some failures. A portion of the spermatogenic tissue is deliberately sacrificed in this operation, and, in the event of infection, the entire testis may be destroyed.

THE PROGNOSIS IN STERILITY

PROGNOSIS IN NON-OBSTRUCTIVE STERILITY

The prognosis in non-obstructive sterility cannot be considered as a whole, since each case presents an individual and often experimental problem. In many of these cases, there is a multiplicity of causative factors, and the treatment must, therefore, be directed along several lines. On the other hand, improvement sometimes occurs spontaneously or as a result of simple hygienic measures. For these reasons, it is difficult to judge critically the merits of any single therapeutic agent. The usual statistical studies are of little value.

The criterion of the cure of sterility is the ability to impregnate. Repeated observations of the seminal fluid, however, serve as a valuable guide in the ultimate prognosis.

The prognosis of non-obstructive sterility varies directly with the ability of the germinal epithelium to regain its function. Irreparable testicular damage may be caused by such a variety of factors as endocrine disorders, vitamin-E deficiency, trauma, x-ray exposure, varicocele, or infectious disease. The finding of necrospermia or oligospermia reveals that some germinal epithelium capable of function remains. In such cases, as contrasted with non-obstructive azoospermia, there is always hope that fertility may be recovered.

Congenital hypoplasia is a hopeless condition at the present time. In cryptorchidism, the prognosis depends entirely upon its correction before puberty, irrespective of whether prolan therapy is used alone or in conjunction with orchidopexy. Definite evidence of fertility was found in 68 per cent. of a series of cases operated on for bilateral undescended testes before puberty.[69] On the other hand, the author was unable to find a single case of undescended testes treated after puberty in which it was established that fertility had occurred.

Marked varicocele should also be corrected early before irremediable testicular atrophy has occurred.

The prognosis in sterility due to endocrinological disorders has improved in recent years. With increasing knowledge, and the purification and standardization of gonadotropic hormones, still better results may be anticipated. Several investigators have observed an increase in the number and motility of the spermatozoa following prolan (anterior pituitary-like sex-stimulating hormone) injections in cases of azoospermia, oligospermia, and necrospermia. The author has also observed such improvement in a number of cases of oligospermia and necrospermia, following prolan therapy. On the other hand, 5 cases of non-obstructive azoospermia so treated showed no improvement.

The prognosis is usually favorable in cases of oligospermia and necrospermia due to fatigue, mental strain, or faulty sexual habits, provided that severe organic lesions have not occurred.

Many cases of sterility can be prevented by the detection and the correction of apparently minor lesions early in life.

PROGNOSIS IN OBSTRUCTIVE STERILITY

Ejaculatory-duct occlusion. The prognosis in cases of true ejaculatory-duct obstruction is very poor. Although rare instances of transurethral dilatation of ejaculatory-duct strictures have been reported, this procedure is difficult, hazardous, and likely to fail.[129, 130]

The prognosis in temporary blockage of the ejaculatory ducts is favorable. Plugs of detritus and inspissated testicular and seminal-vesicular fluid may be successfully evacuated by vigorous massage.[168] In like manner, obstruction of the ejaculatory ducts due to edema and inflammation of the posterior urethral mucosa is often relieved by the instillation of astringents or by fulguration through the urethroscope.

Vas deferens occlusion. The prognosis in occlusion of the intra-abdominal portion of the vas deferens is hopeless. On the other hand, obstruction of the vas deferens in its inguinal and scrotal portions[153] has occasionally been successfully overcome by excision of the occluded portion with end-to-end anastomosis. The prognosis, however, is not very hopeful, because of the small caliber of the anastomosed parts and because of the likelihood of late stricture formation.

Anastomotic operations for epididymal occlusion. The prognosis of vaso-epididymostomy, as a whole, has been discouraging[142, 167, 165, 168] despite the high percentage of successful results reported in isolated series of cases (see page 746 (298–43A).

Vaso-orchidostomy has probably always ended in failure.[170] On the other hand, Lichtenstern and Gara[157] recovered spermatozoa in the seminal fluid post-operatively in 30 per cent. of vaso-orchidocystostomies. Their work, however, has not been confirmed.

Vaso-orchidostomy or vaso-epididymostomy with interposed spermatocele has been performed by the author on 6 patients. Four of these were unilateral and 2 were bilateral. In one of the latter cases, very many normal motile spermatozoa were recovered in the ejaculated seminal fluid 4 months after operation. Aspiration of the artificial spermatoceles in this case revealed many normal spermatozoa on the right side and none on the left. The other bilateral case is too recent to report any result. The remaining 4 cases ended in failure.

Causes of failure of anastomotic operations. Many factors operate against the ultimate success of anastomotic operations. The small size of the structures offers mechanical difficulties. Anastomotic openings between the vas deferens and the epididymal tubule are difficult to make and to maintain, despite a variety of ingenious methods. Late stricture, due to scar-tissue formation at the site of the anastomosis, undoubtedly accounts for many failures.

Vaso-orchidostomy and vaso-epididymostomy with interposed spermatocele were designed to overcome these technical difficulties. However, the author has been unable to devise a satisfactory method whereby the patency of the epididymal tubule, or of the efferent ducts of the rete testis, can be insured. It is probable that some of our failures were due to obstruction of the epididymal tubule, or of the efferent ducts of the rete testis, no spermatozoa reaching the artificially created spermatocele. Implantation of the vas deferens into a naturally formed spermatocele is, of course, much more likely to succeed.

Post-operative hemorrhage is a serious complication and may ruin an otherwise satisfactory operation. Slight oozing from the rete testis or from the epididymis is sometimes hard to control. A large scrotal hematoma was the cause of failure in one of our cases.

Infection, however slight, may be followed by necrosis of the suture line and separation of the anastomosed parts.

A poor result may be due to the inability of the testis to produce normal spermatozoa post-operatively. There is no thoroughly reliable means of determining the functional capacity of the testis at the time of operation. Testicular aspiration is uncertain and epididymal incision does not give trustworthy information as to the quantity or vitality of the spermatozoa. Biopsy of the testis is seldom performed because of the danger of serious damage to the organ. However, even the finding of normal germinal epithelium does not necessarily indicate that the testis will later be able to produce spermatozoa capable of impregnating.

The testis may occasionally be damaged following severe gonorrheal epididymitis. In one of our cases the rete testis was found markedly infiltrated by fibrous tissue. A strand of silkworm gut was passed through this fibrous tissue in the hope of forming a sinus tract between the efferent ducts and the artificial spermatocele. The operation resulted in failure. Aspiration of the artificial spermatocele, 3 months post-operatively, revealed no spermatozoa.

The success of anastomotic operations has generally been judged by the presence of normal motile spermatozoa in the post-operatively collected seminal fluid. Impregnation has more rarely been reported. This raises the question as to whether spermatozoa, passing through a short-circuiting anastomosis — that is, almost directly from the testis into the vas deferens — are capable of fertilizing the ovum and producing normal children. It is not definitely known whether the epididymis adds any secretion to the spermatic fluid during its transit nor whether such secretion is essential for the normal function of the spermatozoon. This information is difficult to obtain in man because of the limited number of anastomotic operations performed and because of the large percentage of failures. In addition, it is important to remember that the scientific control of paternity in animal experiments cannot be applied to man.

Anastomotic operations for the relief of obstructive sterility are still in an experimental stage, and a large series of carefully followed cases are required in order to determine the best type of operation. It seems reasonable, however, that the performance of these relatively non-dangerous anastomotic operations for an otherwise hopeless condition should be encouraged.

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SURGERY OF THE SEMINAL VESICLES, AMPULLÆ, VASA DEFERENTIA AND SPERMATIC CORD

BY

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SURGERY OF THE SEMINAL VESICLES, AMPULLÆ, VASA DEFERENTIA AND SPERMATIC CORD

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CHAPTER I

HISTORY AND LITERATURE

That the ancients were to a certain extent familiar with the seminal vesicles is evident, according to Guelliot, from a passage in the writings of Hippocrates in which the latter alludes to the finding of the seminal fluid on each side of the bladder " in a structure resembling a honeycomb." An expression used by Herophilus has also been supposed to refer to these organs, namely παραστάται κιρσοειδεῖς, that is, *parastatae varicosae,* in contradistinction to *parastatae glandulosae,* or prostates. These references are, of course, too indefinite to have any true historical value, and long centuries elapse before the subject is met with again in the literature.

For the first authentic description of the seminal vesicles we have to wait until the sixteenth century, when Berenger de Carpi (1523) demonstrated that the vasa deferentia, passing behind the bladder, " dilate and form a number of alveoli, which are filled with sperm." He said that he had seen these alveoli and had given them the name of *parastatae cavernosae.* He indicated that they could be found by carefully separating the rectum from the bladder, and gave their number as twelve or more. " Upon incising them," said he, " you will find enough seminal fluid for two or three acts of coitus." The vesicles were regarded by him as simple reservoirs for this fluid.

In 1561 Fallopius not only observed but also dissected the seminal vesicles. He called attention to the ampullæ and to the relations of both these organs to the vasa deferentia. He likened them to a " system of water works " which stores up for ready use a suitable supply of seminal fluid, and pointed out their sacculations and their resemblance in this respect to varicose veins. However, Guelliot, who has made the most complete study in existence of the spermatic tract and its literature, says of this description that " it is scarcely more complete than that of Berenger written thirty-eight years before."

Bauhin in 1605 pointed out the clear function of the vesicles to serve as reservoirs " which bestow upon the male of the human species the privilege of being always ready for coitus."

Ambroise Paré, who dismisses these organs with a few lines, mistook the prostatic utricle for a common orifice of the ejaculatory ducts. He observed that in gonorrhea it was dilated and became "large enough to admit the small head of my spatula."

The description of Habicot (1610) was the most complete so far given. The fact that this author was under the impression that he was the first anatomist to observe and describe the spermatic tract shows how little had been written on the subject previous to his day. According to him "the ejaculatory ducts, upon approaching the neck of the bladder, pass between it and the rectum or erect intestine, then degenerate on each side into a number of cells, placed as if between two covers after the manner of cartridges in which a pistol charge is placed, called *parastatae*, which contain sperm brought from the testicle and epididymis by the aforesaid ejaculatory duct."

Another earnest student of the spermatic tract was Plazzoni, who, in 1621, wrote a description entitled "*De vesiculis seminariis*," in which he stated that the vesicles are hollow and round, for the purpose of containing the greatest possible amount of seminal fluid; that they are membranous, in order to provide expansibility and contractility, and sinuous and varicose in order that the sperm may not flow out spontaneously but be preserved for future use.

Some thirty years later (1656) Wharton, an Englishman, produced a work entitled "*Adenographia*," in which a new view was expressed, called by Guelliot "the exaggeration of a true idea." He thought that the seminal vesicles were glandular organs producing a secretion of their own which differed from that of any other organ; but he also supposed that they had no communication with the vasa deferentia.

In 1668 de Graaf published a book which ushered in a new era in the history of the subject. With him began the accurate study and minute dissection of all parts of the spermatic tract. He was the first to unroll the seminal vesicles and to prove by injections that the right and left vesicles are totally independent of one another. He also showed that an injection made into the vas deferens does not flow out into the urethra until after the vesicle has become completely filled and even turgid with the fluid injected. He thought, however, that the vesicles were merely reservoirs, without secretory function.

His conclusion was disputed by van Hoorne and his commentator Swammerdam, both of whom sustained the view of Wharton that the seminal vesicles are only glands, not storehouses. They also argued that there was no relation whatever between the vesicles and the vasa deferentia.

De Graaf, however, vehemently stuck to his original proposition and published another book on the subject, his "*Partium genitalium defensio*" (1673), immediately after which he is said to have dropped dead in a fit of anger brought on by the dispute. The debate was carried before the Royal Society of England, which indorsed the cause of the celebrated anatomist.

Other writers who opposed de Graaf's view in his own time were Harder (1679) and Taury (1690).

Leal Lealis, in 1726, pointed out the resemblance of the unrolled seminal vesicle to a bird's intestine — a disposition which Winslow, Heister, and all later anatomists have confirmed — but he made the mistake of picturing one common ejaculatory duct. This author protested against the purely secretory view of the function of the vesicles, basing his opinion on the fact that the vesicle and the vas deferens have a common route of evacuation and therefore stand in close relation to one another.

John Hunter revived the whole question again in 1786, when it had almost been forgotten. Basing his argument upon the facts of comparative anatomy, he again tried to prove that the vesicles are only secretory glands designed to furnish some constituent of the semen which the vasa deferentia could not provide. He was supported by a work of Chaptal which appeared the following year.

An important treatise then appeared (1788) from the pen of Brugnone of Turin, a physician and also a veterinarian. Arguing from observations in both human and animal anatomy, he showed the justice of de Graaf's contention regarding the rôle of reservoir played by the vesicles.

These debates, as Guelliot points out, were advantageous in that they called attention to the dual function of the seminal vesicles as reservoirs and also as organs of secretion.

Haller, in 1790, suggested that the seminal vesicles might also play a rôle of absorption, restoring to the blood "that part of the seminal fluid which is most volatile, most odoriferous, and which conveys the most energy." This view was supported by Exner and by Fürbringer, and has more recently been put forward by Königstein (1907), who thought that the vesicular fluid causes changes in old spermatozoa which have remained for a long time in the seminal vesicle, modifying their form and chemical composition, and transforming them finally into eosinophils which enter the blood stream.

Meckel (1787) injected colored fluid into the vesicles, which he was later able to recover from the veins of the small pelvis.

During the first half of the nineteenth century we find the names of Prevost and Dumas, Davy, Weber, and Leydig associated with investigations as to the presence of spermatozoa in the seminal vesicles during life. It was observed that these are found in the vesicles of men and horses, but in those of no other animal. Kayser asserted in 1889 that spermatozoa are not found in living vesicles but only post mortem. Guelliot, however, states that, except in pathological cases, the vesicles always contain spermatozoa during the genital period of the individual's life, and concludes that, as they are not found on the spot, they must come from the vasa deferentia and the lower spermatic tract.

Physiological experiments upon the seminal vesicles have been widely conducted, and in this connection we find the names of such workers as Steinach, Ivanoff, Camus and Gley, Rehfisch, Lode, Remey, and others, who were engaged in demonstrating the glandular activity of these organs. Fick, Loeb, Weber, Virchow, and Kölliker made important studies regarding the contractions of the organs and their rôle in ejaculation. Budge in 1841 identified the centers in the spinal cord that control ejaculation as those of the fourth and fifth lumbar and the first sacral vertebræ. It was Steinach who demonstrated that extirpation of the vesicles in white rats leaves sexual instinct intact but considerably diminishes the reproductive power. Camus and Gley (1899) showed that the sperm coagulates at the moment it unites with the prostatic fluid, and that an important part is thus played by the vesicular fluid in fecundation in the vagina and uterine cornua by a " vaginal plug." Walker confirmed these findings in 1910, and expressed the view that the case is the same in human beings.

According to Chauvin, the first author to make definite mention of inflammatory lesions of the seminal vesicles was Baillie, who, in 1815, recognized " scrofulous and scirrhous degenerescence of these organs."

Albers in 1835 wrote a monograph on the subject of inflammation of the vesicles, and this was followed by the thesis of Faye (1840–41) and later by that of Rapin (1859). Verneuil wrote a text-book on the subject in 1874. The most comprehensive and important contribution of this kind, however, was the thesis written by Guelliot in 1883, which continues to be the most authoritative study of these organs down to the present day.

The clinical importance of chronic vesiculitis as the point of departure for recurrence of gonococcus infection and its septicemic complications was first emphasized by Fuller, who drew attention to this condition in 1903, and in 1905 suggested its relationship to, and responsibility for, gonorrheal rheumatism, together with the possibility of its cure by vesiculotomy and drainage. This was the first recognition of the importance of the seminal vesicles as foci of infection.

The first vesiculotomy had already been done (1888) by Lloyd, who was able to demonstrate, by this means, the frequency of perivesiculitis and of pelvic inflammations following in its wake. In 1893 the procedure was taken up by Fuller, who in 1909 established its definite technic. Fuller upheld this form of surgical treatment on the ground that other natural cavities, such as the bladder, pelvis, gall-bladder, and mastoid, have benefited by the employment of surgical drainage, and that it is therefore reasonable to apply the same principle in inflammatory conditions of the seminal vesicles. The advantages claimed for the method were the wide opening it afforded, the ready evacuation of pus, the possibility of tamponing the wound and the ease of dressing it. By the end of 1913 Fuller had carried out 346 vesiculotomies, and was enthusiastic over his results, especially in articular rheumatism. The method soon came into general use and was adopted by such men as Bentley Squier, Cunningham, Young, Barney, and many others.

Meantime, in 1905, Belfield had introduced the method of injecting antiseptics into the seminal vesicles by simple puncture of the vasa deferentia. His idea was to cut down on the vas in the groin or scrotum, puncture it with a hollow needle, and then inject some suitable medicated fluid into the vas, ampulla, and vesicle. This method came into wide use and, with certain modifications, became the accepted routine method of treatment with a long list of urologists, among whom are found the names of Herbst, Baker, Luys, Kidd, Thomas, Fraser and Goldschmidt, Rolnick, Wolbarst, and C. E. Smith.

In the same year that Belfield introduced vasopuncture (1905), Koltz attempted to inject the seminal vesicles through the ejaculatory ducts, but abandoned the method because of an epididymitis that followed. This delayed the adoption of the procedure until Luys in 1913 drew the attention of the urologists in France to an improved technic that he had developed. Belfield also tried out this route of approach to the vesicles, but appears to have abandoned it in favor of the deferential route. The method has, however, been routinely employed by outstanding urologists, among them Young, Kidd, Delzell, Lowsley, McCarthy, Valverde, von Lichtenberg of Berlin, Phélip in Lyons, and by a host of others, who claim excellent results and assert that the percentage of epididymitis observed after its use is negligible.

In 1912 Picker of Budapest made the first attempts at vesiculography in the cadaver, using collargol and Pick's paste as the opaque substance. This new medium of exploration made it possible to study, as never before, the dimensions, form, and permeability of the seminal vesicles. Picker's studies soon convinced him of the polymorphism of these organs. As the result of his observations he was able to group them in five categories according to the characteristics exhibited in the vesiculogram.

In 1913 Belfield succeeded in outlining the vesicles *in vivo* by injection of collargol, and in the following year reports appeared from Barney and from Thomas and Pancoast that they, too, were using the method successfully. However, the irritating effects of a collargol solution strong enough to give a good image proved a disadvantage. Attempts were therefore made to find a more satisfactory and safer opaque substance, and in 1920 Young and Waters began to employ thorium. At about the same time Belfield and Rolnick, Sicard and Forestier, Astraldi, and others began to utilize iodized oil, especially lipiodol. The remarkably clear images obtained by this new medium soon attracted wide attention.

Vesiculography has now become firmly established as an indispensable aid in diagnosis of spermatic tract pathology. To secure suitable visualization, a large variety of opaque substances have been used, the most common, at the present time, being lipiodol, sodium iodide 10 or 20 per cent., diodrast, skiodan and neo-iopax, in addition to a number of other products on the market for intravenous pyelography, any one of which can be injected into the spermatic tract without danger.

In 1913 Luys introduced catheterization of the ejaculatory ducts for the purpose of diagnosis and treatment of pathology of the seminal vesicles. Like catheterization of the ureters, this has become a routine urological procedure, particularly since the improvement of the cysto-urethroscope, the panendoscope, and the simple endoscopic tube. Other instruments have since been devised for the irrigation of the seminal vesicles, such as needles, catheters, and devices for conducting and directing the latter. These have been employed routinely by Luys, Young, Delzell, Lowsley, Heitz-Boyer, McCarthy and Ritter, and many others.

Meantime, an important surgical procedure — the first vesiculectomy — had been done by Ullmann in 1889. This was a two-stage operation in which a unilateral castration was first carried out, followed, one month later, by removal of the vasa and vesicles through a semilunar incision in the perineum, which was very easily accomplished. The second vesiculectomy was done by Roux 11 months later, and was followed soon after by 2 more by the same operator. Weir, of New York, was the third to carry out the procedure, in 1892; then Schede followed in 1893. Guelliot performed it twice in 1895, and Baudet and Kendirdjy reported a new technic in 1898. Altogether 12 operations of this kind were done in the first 12 years following its origination, and by 1906 the literature revealed 46 cases thus operated upon. Young did his first 3 vesiculectomies in 1901–1902. Other Americans operating about this time were Fenger, 1 case, Walker 1, Bolton 3, and Hutchinson 1. In 1910 Whiteside presented 2 cases and in 1914, 22 more. Voelcker, in Germany, did the first vesiculectomy by the ischiorectal approach in 1912. Young in 1913 presented a radical combined perineal method for use in cases of genital tuberculosis, consisting of the removal of the tuberculous seminal vesicles and prostate and, at the same sitting, carrying out a combined procedure for epididymectomy and complete vasectomy. In 1921 he reported 15 cases so treated, and by 1924 he had an even longer series of cases in which this combined technic had been used with satisfactory results.

The importance of vesiculectomy as a means of removing a dangerous focus of infection was soon generally recognized, and the method was taken up by such men as Squier, Cunningham, Hinman, Keyes, Lowsley, Morrissey and Smith, Marion, von Lichtenburg, Thomson-Walker, Chauvin and Hunt, all of whom have emphasized the good results that have been derived from surgical removal of the vesicles.

In 1929 Gutierrez reported before the annual Congress of the American Medical Association, at Portland, Oregon, the results of 100 consecutive seminal vesiculectomies in which there was not a single death nor any complication whatever. It appears that the method of choice today is the procedure done by the perineal route, as in perineal prostatectomy.

Operations designed for parts of the spermatic tract other than the seminal vesicles have been numerous, and most of them have taken a permanent place in the armamentarium of modern urological practice. Vasostomy, vasopuncture, epididymovasostomy, vasotesticular implantation, bilateral ligation with vasotomy previous to prostatectomy, transplantation of the vas in genital tuberculosis, the Steinach operation for sterility or impotence, ligation of the vas and even castration for hypertrophy of the prostate (particularly for carcinoma) are all accomplishments of modern urological surgery, and will be discussed in this article.

CHAPTER II

EMBRYOLOGY OF THE SPERMATIC TRACT

According to Guelliot, the first anatomist to describe the embryologic development of the seminal vesicles was Rathke, who, in 1825, stated that they were derived from the wolffian body (mesonephros). Rathke was contradicted by other anatomists of his time (Müller, 1829, Coste, 1840, Bischoff, 1842, and Follon, 1850), who regarded them as derived from the müllerian body. His findings have, however, stood the test of time, and they are universally accepted today as sound.

The urogenital fold. From the earliest beginnings of embryonic life to the completion of maturity, the urinary and genital systems are intimately associated in their development, structure, and final relationships. Both have their origin in the mesoderm of the same region, and are first recognizable as the *urogenital fold.* Shortly after this fold has made its appearance on the right and left sides respectively, a division occurs in each fold by which it becomes a lateral mesonephric and a median genital fold. From the mesonephric fold are developed the kidney and other urinary organs, among them the wolffian duct, or primitive ureter, which is destined ultimately to give rise to the spermatic tract in the male but to atrophy in the female with the exception of a few small vestigial structures. From the genital fold, on the other hand, are to arise the müllerian duct and later the gonad, at first indifferent, but subsequently to differentiate into testis or ovary, as the case may be. The müllerian duct is soon to atrophy in the male, leaving only, as vestigial organs, the hydatid of Morgagni (appendix testis) and the prostatic utricle, sometimes called the *uterus masculinus.*

The genital cord. The two urogenital folds early fuse into the so-called *genital cord* which carries both the wolffian and müllerian ducts downward to reach and penetrate the dorsal wall of the urogenital sinus. Up to the age of six weeks there are no specific sexual differences and the embryo is in possession of both male and female genital ducts.

Evolution of the wolffian and müllerian ducts. The first appearance of the wolffian duct is placed at about the fifteenth day

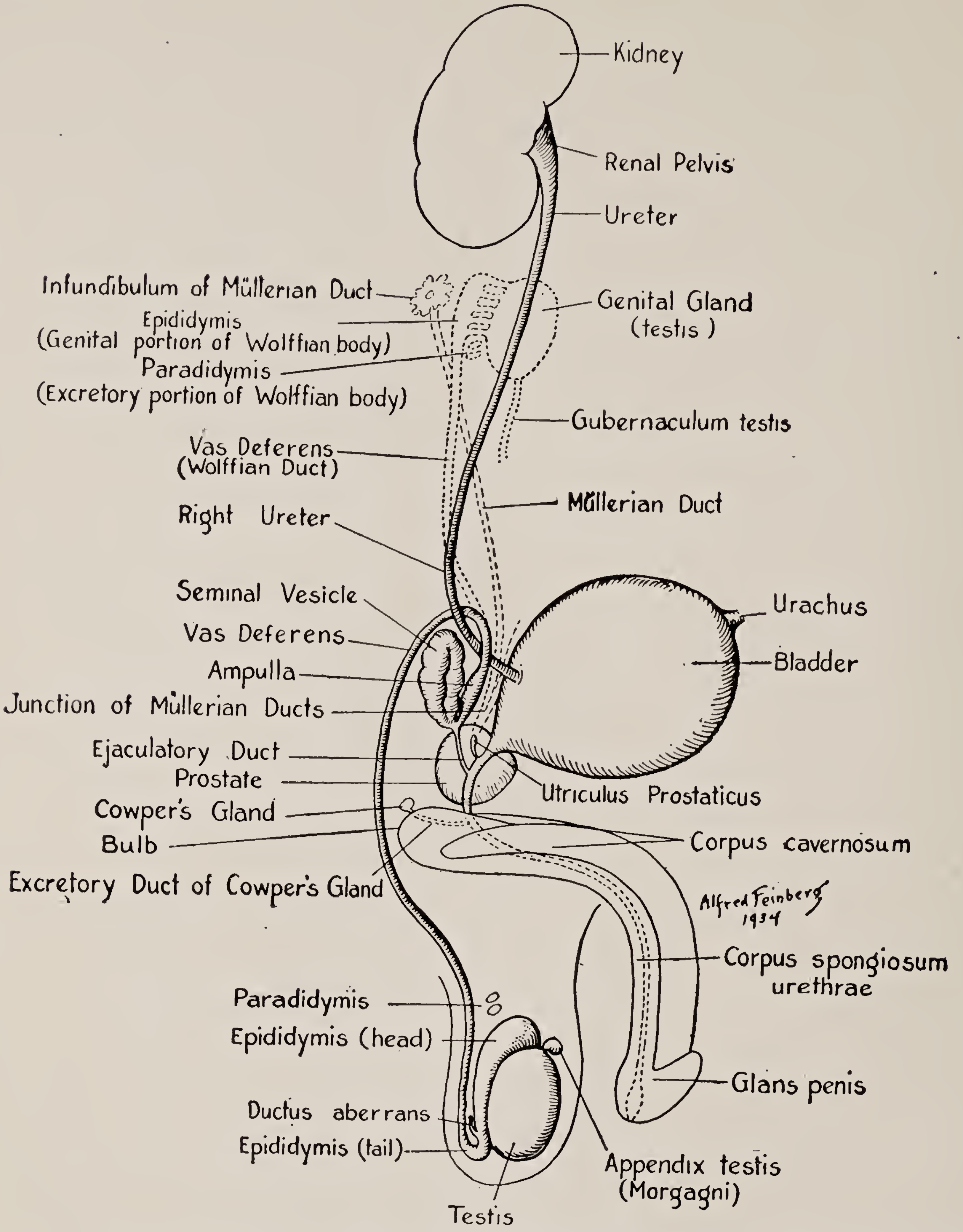

FIG. 1. Embryologic conception of the development and formation of the urogenital tract. During the first stage of life the wolffian body and the müllerian duct are abdominal organs. While the kidney ascends from the bony pelvis to the lumbar region, the testis with its epididymis and vas deferens descends to assume its definitive position in the scrotum. This drawing shows the evolution and migration in the male of the urinary and spermatic tract during its early development. (Redrawn from Sobotas' Anatomy.)

in the development of the human embryo. It is formed from the mesoderm outside of the fourth and fifth provertebræ, and is followed shortly afterward by the transverse canals which constitute the primitive kidney. At approximately the same time, a groove appears in the thickened germinative epithelium of each urogenital fold, which soon assumes a completely tubular form, constituting the müllerian duct. This is first seen passing below, then internal to, the wolffian duct; both ducts debouch into the urogenital sinus below the allantoid swelling which is destined subsequently to form the bladder. At the end of the fourth week the mesonephros, or wolffian body, the second of the three kidneys to be formed, is recognizable as a long ridge or fold of the wall of the thoracic cavity on each side, lying beside the mesentery of the cavity. When the embryo reaches a length of 8 mm., the mesonephros has attained its greatest length, extending from the caudal portion of the lung downward over about 15 body segments. In the lateral part of the mesonephros runs the wolffian duct, the excretory duct taken over from the first kidney (pronephros), which has already disappeared.

The ascent of the kidney. The mesonephros itself, however, is also to disappear, like its progenitor, to make way for the third, or definitive kidney (metanephros), the bud of which develops at the level of the fifth lumbar and second sacral segments, together with the bud of the definitive ureter, which grows out of the caudal end of the wolffian duct, while the duct itself becomes the chief genital duct of the male. As the ureter grows in length, it forces the kidney anlage, for lack of room, to change its position and move upward from its pelvic site to its permanent place in the abdominal region, so that at the end of the second month it is at the level of the first to fourth lumbar vertebræ. By the middle of the embryonic period the top of the kidney has reached the level of the eleventh rib, while the more slowly rising caudal extremity moves gradually toward its final site at the second lumbar vertebra.

The descent of the wolffian duct. While the kidney is thus moving upward, a reverse movement in a downward direction is taking place in the wolffian duct. A progressive degeneration of the tubules in its more cranial portion sets in, while the continued formation of new tubules in a caudal direction gradually causes a wavelike descent until the upper three-fourths are lost, the entire process requiring 4 months for its completion. Throughout this descent the duct, which is losing the greater number of its tubules (which numbered about 80 at their maximum), is being salvaged by the genital system and utilized for new purposes in the male. In the tenth week those tubules that have escaped degeneration again become divided into a cranial and a caudal group. The cranial group, consisting now of 5 to 12 tubules, becomes lengthened downward in marked degree, forming more and more exaggerated convolutions as it goes, until it meets the primordial rete testis and begins to unite with cords of the latter in fetuses of three or more months' development. By the end of the sixth month the lumina of the tubules have become continuous with those of the rete and have been transformed into the efferent ductules of the epididymis. In order to convey spermatozoa from the tubules of the testis into the wolffian duct, what is now the upper extremity of the latter becomes coiled into the duct of the epididymis, while the median and longest portion, originally caudal, becomes the vas deferens. The lowest extremity of this becomes united with that of the opposite side, behind the bladder, by connective tissue fibers.

First descent of the testis. Meantime, the position of the testis undergoes a change during its evolution. In its earliest beginnings the testis is at the level of the diaphragm, from which it extends caudad. The progressive atrophy of its cranial portion results in what may be called a false migration, through a wavelike shifting of the gland caudad, rather than by an actual descent by mass movement. When the shifting process is complete, the caudal extremity of the testis lies at the level of the boundary between abdomen and pelvis. At a later period, however, as we shall see, the position of the testis descends still lower. As the wolffian duct increases in size, the upper portion becomes inclined outward in response to the drag of the testis as it descends toward the inguinal ring, causing the two canals to diverge and form an ever widening angle at the base, behind the bladder.

The bud of the seminal vesicle. About the third month, according to Viault and others, a small bud develops from the genital cord at the inferior and external part of that section of the wolffian duct which has become the extremity of the vas deferens. This bud is at first a simple diverticulum of the vas, which gradually grows until it becomes the future seminal vesicle. The time of its appearance, however, is far from being constant, since fetuses exist in which at the third month there is still no sign of any such bud formation. Guelliot saw in a fetus of three and one-half months (15 cm.) a quite evident vesicle outside of the very minute vas deferens. It resembled a small hollow cavity in the muscular cord which surrounds the vas. The mucosa scarcely existed, and the epithelium was clearly cylindric, with cells that were two to three times as high as they were wide.

Development of the seminal vesicle. From the fourth to the fifth months of embryonal life the vasa deferentia are nearly horizontal at their termination, then turn suddenly inward to enter the prostate. The seminal vesicles are attached to the end of this latter portion, where they look like small tuberosities 2 mm. long and 1 mm. wide, slightly sacculated and nearly horizontal. One of Guelliot's sections showed that only two or three alveoli are in existence at this time, the thickened walls of which are fused with those of the vas internally. Externally they consist only of a loose cellular tissue and vascular tissue, not yet condensed into fibrous tissue. The mucous chorion is very thin, the epithelium is cylindric and contains a nucleus and fine granulations. The vesicle grows rather slowly in size, as the tube out of which it is developed continues to roll out more and more and to push out appendages. These, together with small branching diverticula, begin to appear at the end of the fourth month, and by the middle of embryonal life the vesicle has practically assumed its definitive form. This is true also of the ampulla, which forms similar diverticula, but smaller. At birth the vesicle measures 7 to 12 mm. in length and 4 to 8 mm. in width.

Second descent of the testis and spermatic cord. Between the seventh and ninth months the testis descends again, this time by a rapid mass movement, into the scrotum, bringing with it the vas deferens and the group of spermatic vessels and nerves which, with it, compose the spermatic cord. This carries the epididymal end of the vas, which was at first above the ampullar end, down to its final resting-place at the level of the base of the epididymis and testis, the vas now passing in front of the ureter and down through what is to become the inguinal ring into the scrotum, where it turns abruptly upward again in a very narrow angle into the tail of the epididymis, while the ampullar end of the vas remains fixed behind the bladder, together with the seminal vesicle and ejaculatory duct.

CHAPTER III

ANOMALIES OF THE SEMINAL VESICLES AND SPERMATIC TRACT

In addition to the wide range of normal variations in the form, capacity, and lumen of the convoluted seminal vesicle, in the incidence and number of sacculations, and in the position assumed by the ejaculatory duct in its relation to the vesicle and ampulla, all of which naturally have their bearing upon the pathology of these structures and of the entire spermatic tract, there are certain definite gross anomalies that are encountered with more or less frequency in the organs that make up the tract. Most of these anomalies affect more than one organ, and are of interest only because of their coincidence, revealing their relation to arrests of development during embryonic life. It would be a mistake, however, to believe that the absence of a seminal vesicle presupposes the absence of a testis, for it should be remembered that the seminal vesicle is only a bud at the extreme end of the vas deferens, upon which the formation of the testis is in no way dependent. It is, in fact, more common to find absence of a seminal vesicle and vas associated with absence or arrested development of a kidney than with absence of a testis, the cause lying far back in the period of the mesonephric duct.

TYPES OF CONGENITAL ANOMALIES

The following types of congenital anomalies have been reported in the literature of the subject:

Absence of both seminal vesicles. Schwarzwald (1928) found 8 cases of this kind in the literature; in 4 of these the prostate also was wanting. In 2 cases, according to Guelliot, there was absence of the entire spermatic tract, including both testes. The latter author also collected a number of cases in which both testes were present but both seminal vesicles absent, with concomitance of other anomalies as follows:

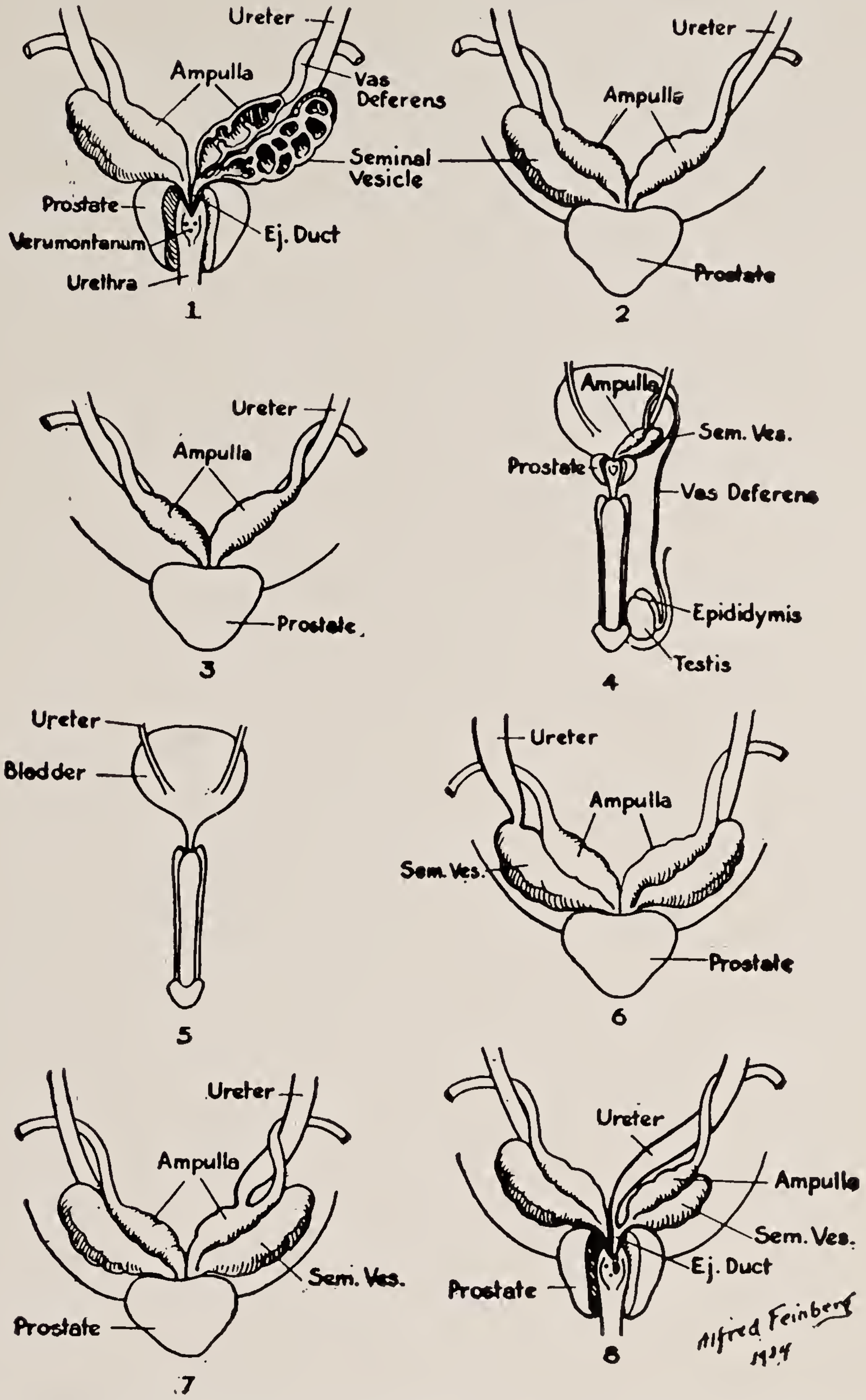

FIG. 2 A. Classification of the anomalies of the seminal vesicles and spermatic tract as collected from the literature.

1. The normal type of vesicles, ampullæ, and their adnexa.
2. Absence of one seminal vesicle.
3. Absence of both seminal vesicles.
4. Absence of one-half of the spermatic tract, including one seminal vesicle, ampulla, vas deferens, testis, epididymis and ejaculatory duct.
5. Complete absence of spermatic tract, including prostate and verumontanum.
6. An ectopic ureter opening into one of the seminal vesicles.
7. An ectopic ureter opening into one of the ampullæ.
8. An ectopic ureter opening into one of the ejaculatory ducts.

(1) Exstrophy of the bladder, with the vasa deferentia terminating in a cul-de-sac behind it.

(2) Testes displaced near the suprarenals, absence of anus, kidney, seminal vesicles, bladder, and prostate.

(3) Testes small, both seminal vesicles rudimentary.

(4) Imperforate rectum, vasa deferentia becoming lost on the lateral walls of the bladder.

(5) Absence of prostate and penis. Vasa deferentia terminating in a hard tubercle near the internal iliac vessels.

(6) Hermaphroditism, left testis alone present, vas deferens infantile.

(7) Coalescence of the two vasa, presence of only one ejaculatory duct.

(8) Undescended testis, hypospadias, absence of prostate and prostatic utricle.

Absence of one seminal vesicle. This condition is more frequent than bilateral absence of the seminal vesicles, Schwarzwald having found 54 cases in the literature. Congenital anomalies of the kidney were present in most of these patients, and in 9 there were no testes.

Absence of one-half of the spermatic tract, including one of the seminal vesicles and one of the ampullæ, vasa deferentia, testes, epididymes, and ejaculatory ducts. Five cases were collected by Schwarzwald in which the vas was absent: in 2 of these the seminal vesicle was also lacking; in 1 case the vesicle was present, but functionless; in the other 2 it was present, but in only a rudimentary state. McMahon has recently reported a case in which the right seminal vesicle, vas deferens, and ejaculatory duct were absent, while the testis was present.

Complete absence of the spermatic tract, including the prostate and verumontanum. Among 19 cases of anorchidism, Guelliot observed 6 in which the entire spermatic tract was absent.

An ectopic ureter opening into one of the seminal vesicles. At the beginning of their development the ureter and vas open for a few days into the urogenital sinus by a common orifice. Disturbances at this time may result in anomalies of these organs. Hoffmann observed a case of double ureters, one of which was dilated behind the bladder into a pouch occupying the place of a normal seminal vesicle. The pouch was at first separated from the vas by a thin partition; then opened, like the normal ejaculatory duct, into the lateral parts of the verumontanum. It is difficult to say

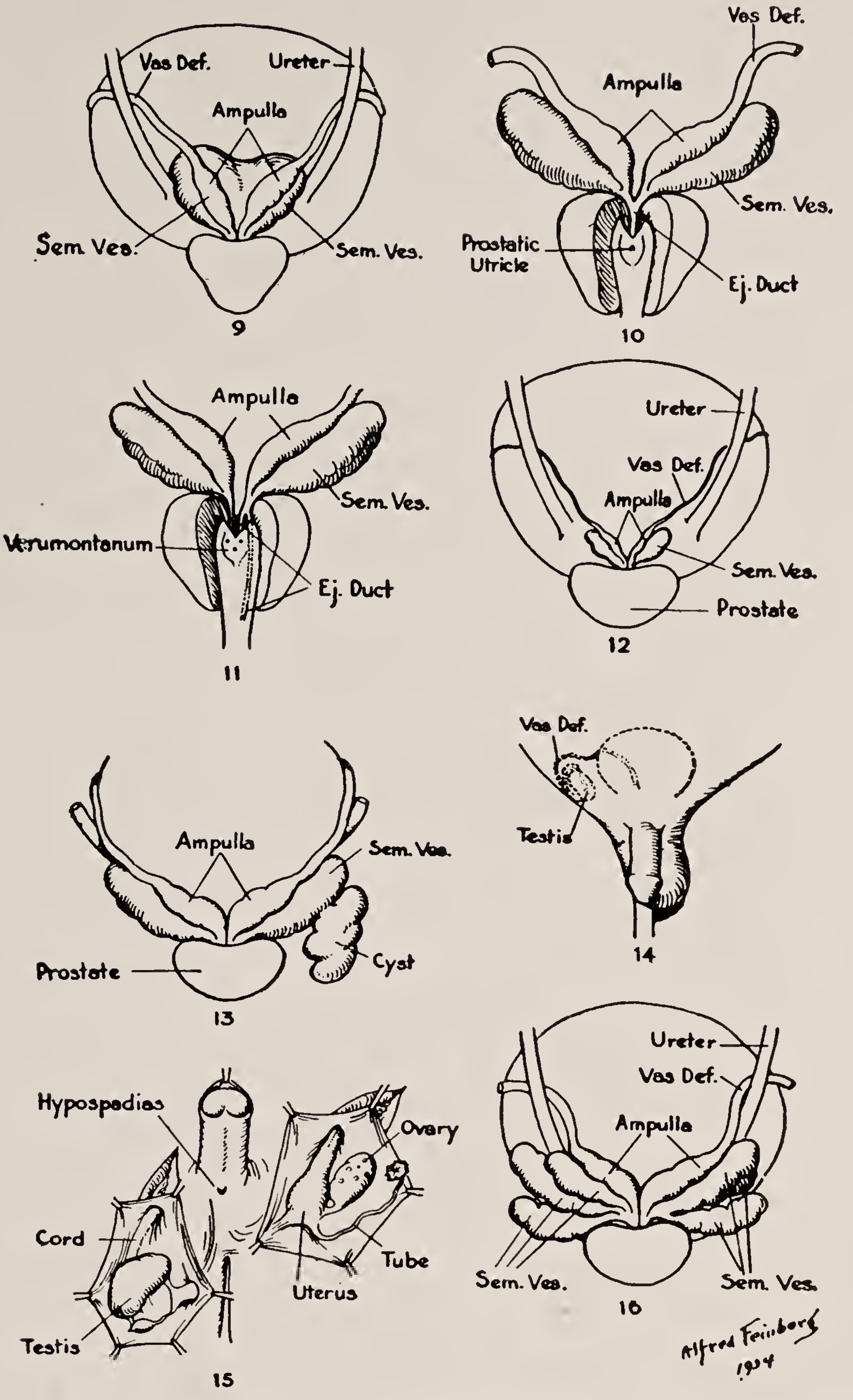

FIG. 2 B. Classification of the anomalies of the seminal vesicles and spermatic tract as collected from the literature.

9. Fusion of both seminal vesicles.
10. Fusion of the two ejaculatory ducts to open in one orifice at the utriculus prostaticus.
11. An additional ejaculatory duct opening into the membranous urethra.
12. Hypoplastic or undeveloped seminal vesicles, ampullæ and vasa deferentia.
13. Cyst or diverticulum of one of the seminal vesicles.
14. Undescended testes and vasa deferentia.
15. True hermaphroditism, showing male and female genital organs in a male.
16. Multiple seminal vesicles (2 or 3 on each side.)

whether here the pouch was a dilatation of an abnormal ureter or an actual seminal vesicle that had budded simultaneously with the uretero-seminal canal.

To this case Dossot has added 8 new ones, 6 of which were cases of unilateral ectopia, 1 a case of supernumerary ureter, and the eighth an unusual case of double ectopic ureter of the same side opening into the corresponding seminal vesicle. Among these cases was one of Papin's in which the right ureter, which opened into the right seminal vesicle, corresponded to a right hypoplastic kidney.

An ectopic ureter opening into the ampulla or vas deferens. Seventeen cases of this kind were collected by Schwarzwald. Dossot more recently collected 6 new cases: 4 were ectopic simple ureter; in 1 of the others the ectopic ureter was supernumerary, and in the remaining case the abnormal abouchement was bilateral.

An ectopic ureter opening into the ejaculatory duct or into the prostatic utricle. Dossot of the Necker Clinic has reported 3 cases, in 1 of which one of the two ureters opened into the ejaculatory duct, while in the other 2 cases there were three ureters, two of which opened normally into the bladder, and the third of which was ectopic, opening into one of the ducts. He also mentions 3 cases in which the ectopic ureter opened into the utriculus prostaticus at the verumontanum. In 2 of these cases, one of which was reported by Rémy and Barth and the other by Bostroem, a supernumerary ureter from a cystic kidney opened by a large orifice into the utricle, while in the third case, reported by Verliac, there were two ureters on each side; three of the four opened normally into the bladder, and the remaining one, on the left side, passed into the left lobe of the prostate and thence into the utricle.

In a case reported by Eppinger there was a rudimentary kidney (five tubules), the ureter of which opened into the ejaculatory duct.

Fusion of the two seminal vesicles. Two cases of this kind have been reported in the literature (Schwarzwald), neither one of which, however, is entirely convincing.

Fusion of the two ejaculatory ducts. This was regarded by the early anatomists as a normal condition, but is now known to be absolutely exceptional, and observed only when other anomalies of the spermatic tract exist. Thus Hyrtl saw a case with both seminal vesicles absent, in which the vasa deferentia met and united behind the bladder for a distance of 25 mm., forming an asymmetric dilatation. At the posterior border of the prostate this pouch diminished in size and terminated in a solitary conical duct whose urethral opening was on the crest of the verumontanum. Quatrefages also claimed to have observed the two ejaculatory ducts fused within the prostate. The fusion may occur at the point of entrance into the urethra. Cases have been observed in which the two ejaculatory ducts opened within the cavity of the prostatic utricle. McKenna and Kiefer, in 1939, reported a case of congenital enlargement of the prostatic utricle with inclusion of both ejaculatory ducts and both seminal vesicles, revealed by vesiculography. Cruveilhier, Vesalius, Testa, and others have reported cases in which the two ducts fused into a single canal running the entire length of the penis and opening only upon the glans itself, an upper canal discharging semen and a lower one urine, as if constituting a double urethra.

Supernumerary ejaculatory ducts opening into the membranous urethra have also been reported in the literature, in which the ducts resemble the minute ducts of Cowper's glands, for which they have been mistaken.

Hypoplastic or undeveloped seminal vesicles, ampullæ, and vasa deferentia. Schwarzwald collected 8 cases in which the seminal vesicles were only rudimentary: 6 of these were unilateral and 2 bilateral.

Cyst or diverticulum in one of the seminal vesicles. Vesicles are sometimes observed in which the sacculations are so large as to constitute veritable diverticula. In one case observed by Guelliot, a structure of this kind was comparable to an accessory seminal vesicle protruding from a normal one. In another case, the vesicle was so deeply lobulated that there seemed to be two right vesicles, as the result of premature bifidity of the organ. According to Picker, 33 per cent. of all seminal vesicles have what may be called large grapelike diverticula. Francke observed at autopsy a malformation which could only be regarded as a multilocular cyst of the seminal vesicle. Very minute congenital cysts have also been found within the vesicular wall, especially in its deep layers (Wassiljeff).

Undescended testes and vasa deferentia. The testes may remain within the abdomen, undescended, in which case the vasa and the vessels and nerves forming the spermatic cord also remain in an abnormal position.

True hermaphroditism. Rarely, ovaries and testes may both develop in the same individual, but, according to Arey, functional competency of both male and female glands has never been demonstrated.

Pseudo-hermaphroditism. A number of cases have been reported of males in whom the entire spermatic tract was absent and in whom, upon opening the abdomen, female genital organs have been found.

A case was reported by Haines of Philadelphia of a male school-teacher, 50 years of age, with penile hypospadias and absence of both testes from the scrotum, who was operated on for an abdominal tumor. When the abdomen was opened, a fibroid uterus the size of a five-months' pregnancy was found, with normal ovaries and tubes, and a rudimentary vagina. There was no trace of any spermatic tract.

In cases of this kind it is impossible to determine the sex of the individual without an exploratory laparotomy, but there is strong probability that whenever a hypospadias is present, associated with absence of testes from the scrotum, we are dealing with a case of pseudo-hermaphroditism.

Multiple seminal vesicles. Individuals are occasionally found in whom there are two, or even three, seminal vesicles on each side; or there may be multiplicity of vesicles on one side and one normal vesicle on the other.

Importance of unrecognized anomalies. To the great variety of congenital malformations of the spermatic tract can be attributed, no doubt, many unrecognized lesions and pathological conditions of the tract, and these cannot fail to play an important part in sterility, impotence, and painful states related to this physiological function. These abnormalities reveal the close embryologic relationship between the urinary and spermatic tracts, especially when one notes how often there is recorded in the literature a ureter opening into some part of the spermatic tract and the extensive pathology resulting therefrom, as is graphically illustrated in Figures 2 A and 2 B.

CHAPTER IV

ANATOMY AND TOPOGRAPHICAL RELATIONS OF THE SPERMATIC TRACT

Essentially, the spermatic tract is formed by the testis, epididymis, vas deferens, ampulla, and seminal vesicle, together with the ejaculatory duct, which empties the spermatozoa into the prostatic urethra at the verumontanum during ejaculation. The vesicles are the reservoirs of the semen, as the bladder is of the urine. The ampulla and vas deferens are known as the adnexa of the vesicle.

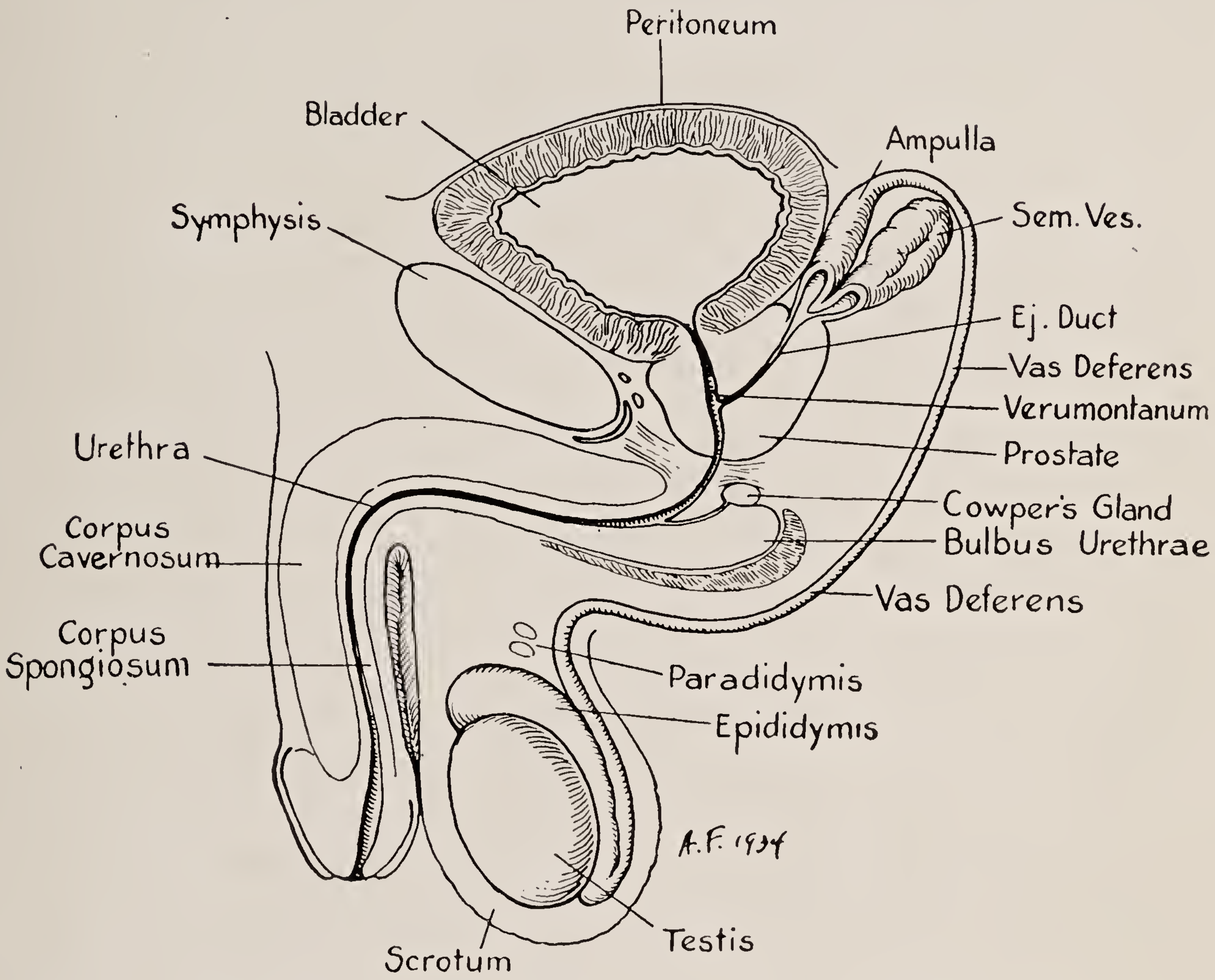

Fig. 3. Schematic drawing of the spermatic tract, including seminal vesicle, ampulla, ejaculatory duct, vas derefens, epididymis, testis and its other anatomical structures. Note its intimate relation with the lower urinary tract.

THE SEMINAL VESICLES

The seminal vesicles are two symmetrical lobulated pouches situated within the pelvis minor at the right and left of the median line, between the bladder in front and the rectum behind, above the level of the prostate and below the pelvic peritoneum, which is supported by their upper extremities. Their tapering lower extremities meanwhile approach one another to empty their contents through the ejaculatory ducts into the prostatic urethra at the verumontanum, which they enter through two small orifices

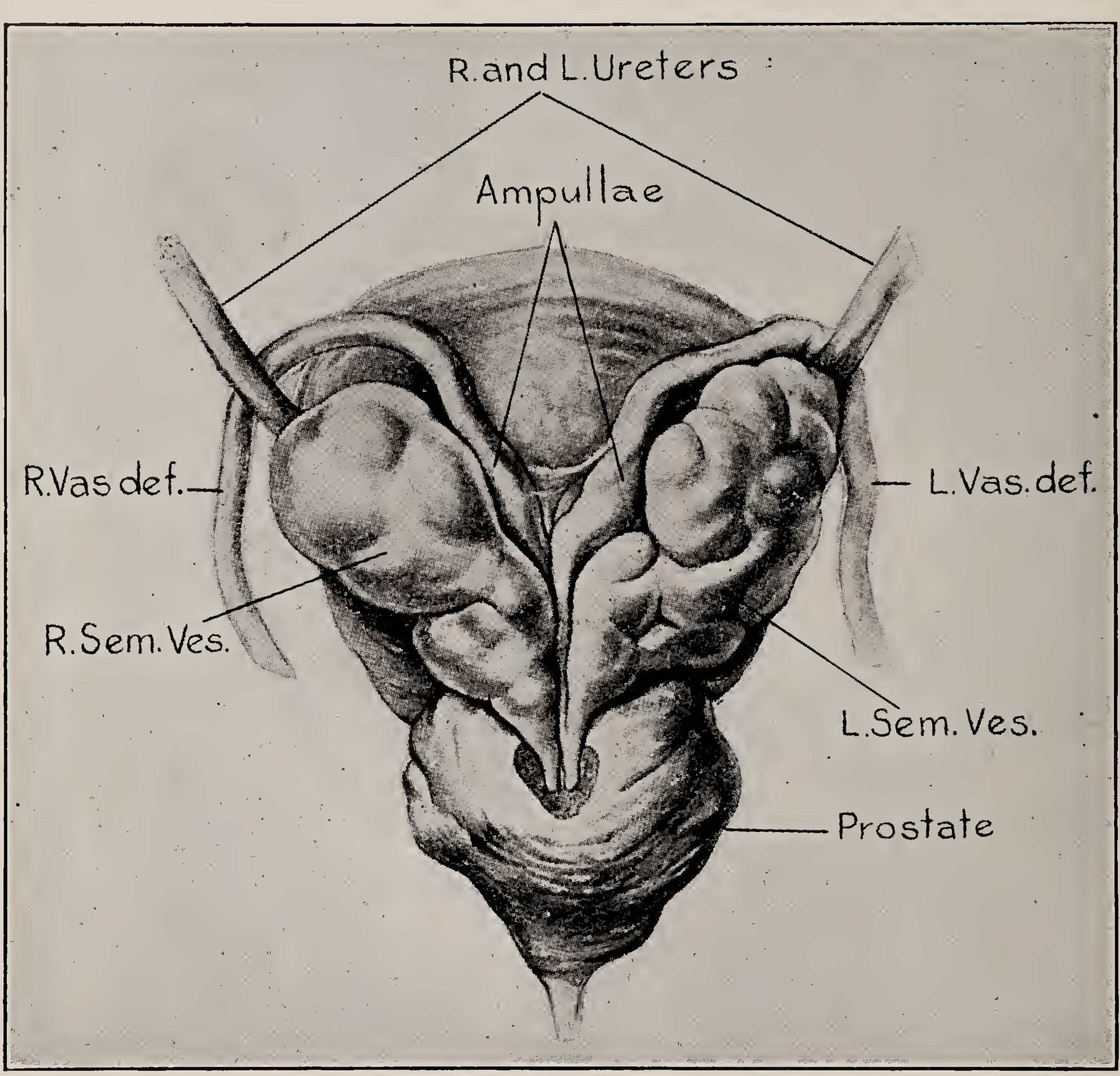

FIG. 4. Normal posterior aspect of the seminal vesicles, ampullæ, and vasa deferentia, showing their intimate relation with the ureters, bladder, and prostate. (From Luys: *Maladies de la Prostate*, 1926.)

at the right and left of the prostatic utricle. The two vesicles, which are of a rose-gray color *in vivo*, are united to one another and to the ampullæ of the vasa deferentia by a common capsule.

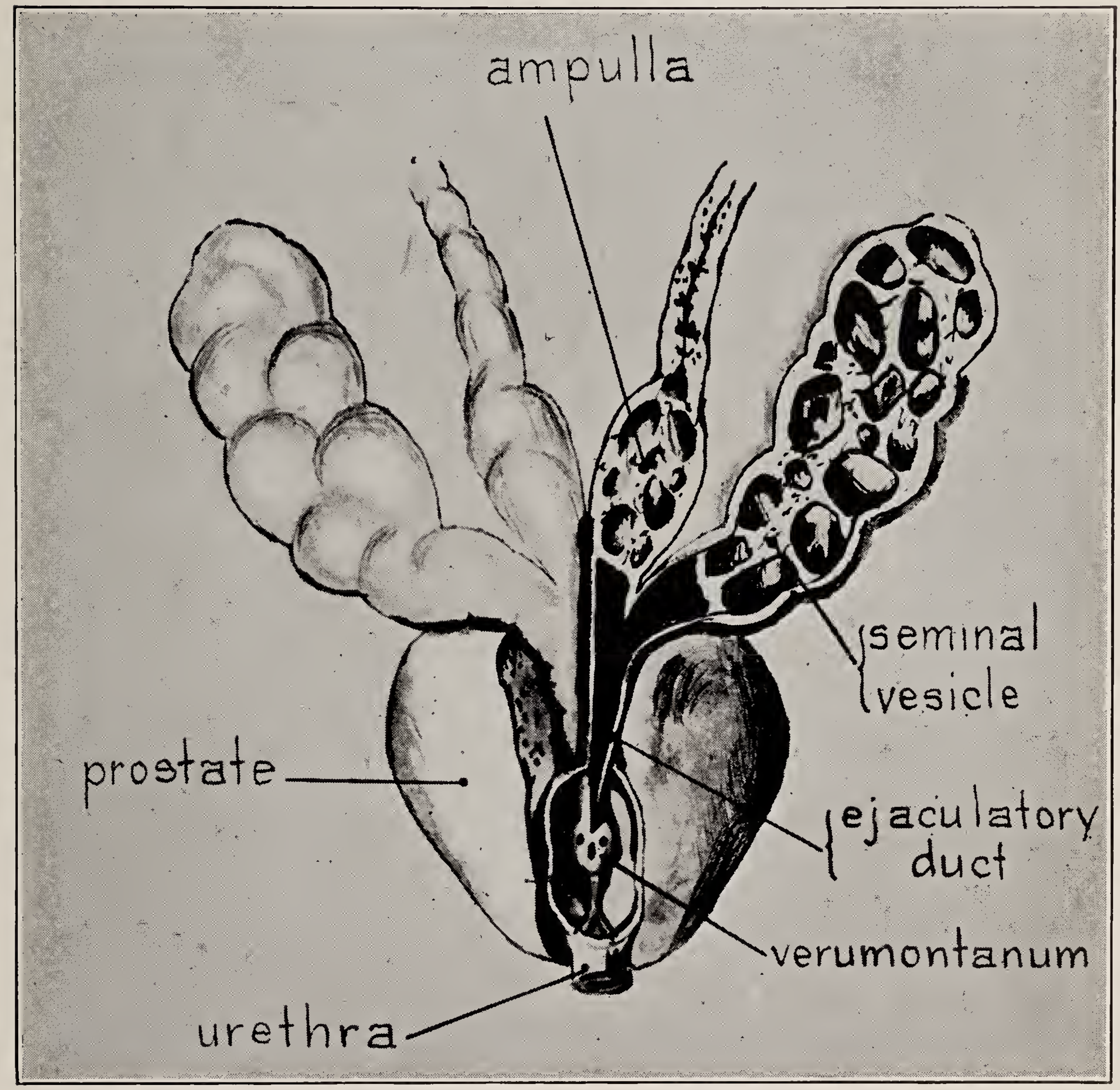

Fig. 5. Form and gross structure of the seminal vesicles and ampullæ, showing their intimate anatomical relation with the prostate, verumontanum, and ejaculatory ducts.

Form and gross structure of the seminal vesicles. Viewed externally, the seminal vesicle appears as a small oblong organ, somewhat resembling an elongated pear, slightly flattened in its anteroposterior dimension. It lies against the posterior aspect of the bladder, with its large end at the top and leaning outward, its small end at the bottom leaning inward.

The entire surface of the vesicle is sacculated, so that its appearance has been likened by Fallopius to a mass of varicose veins, by Lealis to loops of intestine, and by Dionis to a bunch of grapes. In the normal state it is seen with its internal border pressed closely against the ampulla of the vas deferens, which runs a parallel course along the upper and interior aspects of the vesicle and is bound to the latter by cellular fibers of a rather fragile consistency. On its external aspect the normal vesicle is rounded and presents a compact appearance. It is subject, however, to wide variations of form, which become evident as soon as dissection is undertaken.

Internal structure of the seminal vesicles. Internally the seminal vesicles appear as alveolar organs, consisting of a long principal tube, rolled up and convoluted upon itself in deep lobulations which are filled with intercommunicating cellules or alveoli incompletely divided by septa. These alveoli are in turn subdivided by trabeculæ into secondary alveoli, the whole having the appearance of a honeycomb, to which Hippocrates, as we have already seen, likened it. Dionis compared the arrangement to the cavities within a pomegranate. According to Leal Lealis, the cellules are 8 to 10 in number, but Faye counted 16 and Haller 17.

THE ADNEXA AND THEIR RELATION TO THE SEMINAL VESICLES

In very intimate association with the seminal vesicle are its adnexa, the *ampulla of the vas deferens* and the *vas deferens proper*, lying within the retrovesical space between the bladder and the rectum.

As it is impossible to understand the seminal vesicles without them, these adnexa and also the *ejaculatory ducts* and the *verumontanum* must be briefly touched upon at this time, before proceeding to the anatomical details of the seminal vesicles themselves.

The ampullæ. Between the two seminal vesicles and in intimate contact with them, at the right and left of the median line, lie the two ampullæ of the enlarged and convoluted vasa deferentia. Arriving laden with their seminal content from the testes, the vasa, one on the right and one on the left, first approach the vesicles from the external and superior aspect of the latter, passing in front of the ureters over the posterolateral aspect of the fundus of the bladder, then following the contour of the superior and internal aspects of the vesicles, in two oblique lines, as the lower end of each vesicle approaches its mate. The ampullæ accordingly occupy the space between the vesicles and become united to them at a very acute angle, each ampulla being separated from its vesicle by a long, slender spur as it meets the latter and unites with it to form the right and left ejaculatory ducts respectively at the upper surface of the prostate.

The angle at which the ampulla and vesicle merge to form the ejaculatory duct is such that the duct of the seminal vesicle is a direct continuation of the ejaculatory duct, while the ampulla is only a tributary.

Recent studies by McMahon on specimens obtained fresh from autopsy have demonstrated beyond a doubt, in a long series of vesiculograms, that although this angle may vary somewhat, the lumen of the ejaculatory duct is essentially a continuation of the tapering duct of the seminal vesicle. This author also showed that the ampulla of the vas always joins the seminal vesicular duct with a constricted lumen, so that, upon injection of fluid through an ejaculatory duct, the vesicle always fills first, before the fluid can enter the vas by retrograde injection. This constricted lumen of the vas seldom measures more than 1 mm. in diameter for the last millimeter or two, while the lumen of the seminal vesicular duct averages 4.5 mm.

The vasa deferentia. These organs, which have been improperly called the excretory ducts of the testes, have their origin in the necks of the corresponding left and right epididymes, of which they are, in fact, the prolongations. From these they extend to the necks of the respective seminal vesicles, dilating at their distal ends, as we have seen, to form the ampullæ of the vasa.

The course of the vas is long and sinuous, and has for convenience been divided into 4 tracts: the *epididymal*, *scrotal*, *inguinal*, and *abdominopelvic*. As it leaves the epididymis, it is at first directed obliquely downward and inward, parallel to the internal aspect of the testis; near the base of the latter it completely reverses its course and turns sharply upward and outward in an oblique direction, in a line approximately parallel to its initial course and to the internal aspect of the epididymis. This is the *epididymal*, or testicular, portion of its tract.

Having reached a point corresponding to the middle of the epididymis, the vas straightens its course and, together with the other elements that make up the spermatic cord, passes upward in a vertical direction as far as the external orifice of the inguinal canal, which it enters along with the vessels and nerves that supply it. This portion of the vas, up to the external orifice, is known as the *scrotal*, or funicular, tract. Passing into the inguinal canal from below, the vas now enters upon its third, or *inguinal*, tract, still accompanied by all its fellow elements in the cord. The course now swerves slightly outward in order to pass through the entire length of the iliac fossa. Upon emerging from the inguinal canal the elements composing the spermatic cord become dissociated and the vas, now in its fourth, or *abdominopelvic*, tract, accompanied from this time on only by the spermatic artery, describes a curve as it follows along the inner concavity of the similar curve of the epigastric artery in its initial position; it then passes within the

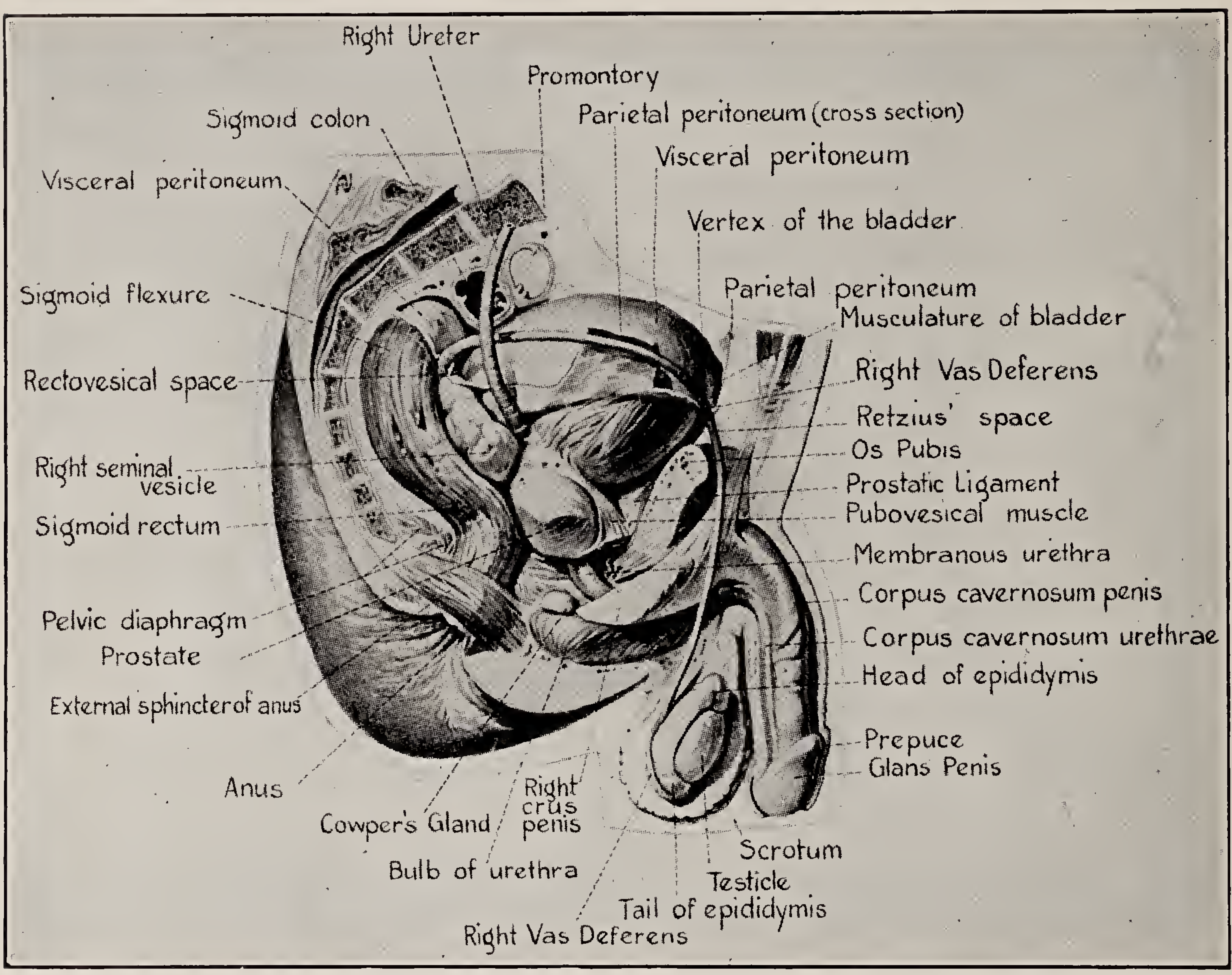

FIG. 6. Sagittal view of the organs constituting the spermatic tract and their relation to contiguous structures. This drawing shows the 4 anatomical positions that the vasa deferentia occupy in their course from the *abdominopelvic* position to the *inguinal*, *scrotal*, and *epididymal* regions. (From Braus: *Anatomie des Menschen*, 1934.)

external iliac veins, goes laterally and obliquely downward across the posterior aspect of the bladder and in front of the ureter, below which, dilating into the ampulla, it ends its course internally to the seminal vesicle, with the outlet of which it merges to form the ejaculatory duct.

The ejaculatory ducts. The ejaculatory ducts, two in number, one on the right and one on the left side of the median line, are formed by the union of the ampulla of the vas deferens with the neck of the seminal vesicle on their respective sides. They are very elastic bodies, and their function is to carry into the prostatic urethra the semen that has been collected in these seminal reservoirs. Starting at the union of the vas and seminal vesicle, each duct takes an oblique course downward, forward, and inward, and converges toward its mate as it terminates in the interior of the prostate, through which the two ducts run a parallel course, until they debouch in two separate punctiform openings upon the right and left lips respectively of the prostatic utricle at the level of the verumontanum.

The verumontanum. The verumontanum is a small, striking, and very vascular eminence of an oblong shape on the floor of the posterior urethra, sometimes known as the *colliculus seminalis*, upon the anterior slope of which the prostatic utricle and the two ejaculatory ducts open, the former in the midline, and the duct orifices at its right and left respectively. According to studies carried out by McCarthy, Ritter, and Klemperer, the duct openings are in 80 per cent. of cases more anterolateral than lateral, in 5 per cent. lateral, and in 15 per cent. posterolateral.

Direction of the seminal vesicles. The seminal vesicles usually follow a doubly oblique direction, forming with the vertical line an angle of about 45° and at the same time extending downward, forward, and inward. This direction varies, however, according to the fullness of these reservoirs and of the bladder, and also according to the age and general condition of the individual.

According to Guelliot, they are nearly horizontal at birth and during early infancy, but as the bladder develops they begin to rise until, at puberty, they have become nearly vertical, only to incline again when full maturity is reached. They maintain this oblique position during the entire genital period, but as old age comes on they frequently tend to resume their early horizontal direction.

Size of the seminal vesicles. In size, the vesicles vary greatly, according to age and individual constitution. Small in childhood, the vesicles rapidly increase in size at puberty. They remain at maximum during the period of genital activity, then undergo involution in old age, when they may become dilated or may undergo fibrous transformation to complete atrophy. According to the extent of the genital activity, the size will vary in different individuals during adult life; but it will also vary in one and the same individual according to the fullness or emptiness of the vesicles.

The average dimensions in a healthy adult have been given by Guelliot as: length 49 mm., breadth 18.5 mm., thickness 10 mm. But there are extreme cases, according to this author, in which the length has reached 65 mm. and the breadth 35 mm., and other cases in which these dimensions have measured as little as 40 mm. and 12 mm. Chauvin regards 5 to 6 cm. as a fairer statement of their average length, while Luys mentions a case in which the length of a vesicle reached 11 cm. In men over 60 years of age, according to Duplay, the average length is only 44 mm. and the breadth 13.5 mm.

The average cubic capacity of the seminal vesicles has been placed at 1.5 to 3.0 cc. although they have frequently been seen as large as 7 cc. Picker, in a study of 72 cadavers, found a variation of the average cubic contents from 5 cc. to 11 cc. for a single vesicle.

The two vesicles are seldom of the same size; for no known reason, the right vesicle has oftener been found to be the larger than vice versa.

Dimensions of the vesicular tube when unrolled. Upon careful dissection the tube of the seminal vesicle, when unrolled, is found to measure, upon the average, 10 to 15 cm. in length and 5 to 7 mm. in width. Cruveilhier, however, saw such a tube 32 cm. long. The width is nowhere uniform, as the caliber of the tube is constantly changing, owing to the presence of a great number of minute projections and depressions visible even to the naked eye, giving to the vesicle, especially in the portion adjacent to the vas, a well-ordered areolar appearance. The manner in which the vesicle is rolled up presents every kind of variation. De Graaf and Leal Lealis saw in it the arrangement of a bird's intestine, and the latter accordingly gave it the name of *intestinalium seminalium*. It may fold upon itself until its cecum approaches its origin; in some cases the circumvolutions extend from the neck of the bladder to its fundus.

Diverticula of the seminal vesicles. A remarkable feature of the vesicles is the presence of diverticula, 6 to 10 in number, which protrude here and there along the external surface of the sinuous tube, sometimes reaching a length of 3 to 4 cm. (Sappey). Although variable in disposition and number, there is one of these prolongations which is almost constant and which sometimes takes on an exaggerated development. This is the one nearest to the origin of the canal, close to the vas deferens. Guelliot observed one of these that actually formed an accessory vesicle. These appendices may be simple, bifid, or more or less ramified. Huschke observed that while they are sometimes arranged in a somewhat regular pattern along the principal canal, they are quite frequently more numerous inside the tube at its lower extremity and on the outside of the tube at its upper extremity.

Appearance under insufflation. Guelliot was able to make an excellent study of the internal arrangement of the vesicles in the cadaver by injecting them with a solidifying substance, or, even better, by *insufflation.* After separating as carefully as possible the vesicles, ampullæ, and ejaculatory ducts from the surrounding tissues, he expressed the semen and then injected water through the vasa several times, after which he placed a ligature upon the ejaculators. He then insufflated them through the vasa and suspended the preparation where it was well exposed to ventilation. At the end of two or three days the dessication was complete, and it was easy to make longitudinal and transverse sections with a razor, in which the depressions and prominences, even down to the smallest folds of the wall, could be seen admirably under the microscope. He stated that this is the only kind of preparation that visualizes satisfactorily the connections between the seminal vesicle and the ampulla and ejaculatory duct.

Varieties of structural types. Picker, who made a report in 1919 on 150 seminal vesicles which he had examined after injecting a solution of collargol or other opaque substance, divided these organs into 6 types:

(1) Vesicles in which the principal canal is simple and straight, without sinuosities. They are short (2 to 4 cm.), and have a cubic capacity of 4 to 6 cc. Such vesicles are found in only about 3.5 per cent. of individuals.

(2) Vesicles consisting of a long, wide, and tortuous canal, that may reach a length of 23 cm. with a capacity of 5 to 12 cc. These are found in 15 per cent. of persons.

(3) Vesicles in which the principal canal is narrow but long and

tortuous, without diverticula, or, if any are present, of no significance. These he found in 15 per cent.

(4) Vesicles either straight or tortuous, well developed, but having large grapelike diverticula: 33 per cent.

(5) Vesicles with a short principal canal but characterized by large ramified diverticula: 33 per cent.

(6) Various congenital anomalies and pathological types.

Anatomical structure of the seminal vesicles. The vesicles, the corresponding terminal portions of the vasa deferentia, and the ampullæ all possess the same anatomical and histological structures. They are embedded in an areolar tissue that constitutes a net of fascia, and are covered by the two layers of the so-called prostatoperitoneal aponeurosis or the fascia of Denonvilliers, which runs from the apex of the prostate to about the base of the bladder, where the two layers coalesce and continue as the peritoneum. A few transverse fibers that join the bases of the two vesicles raise up the serous membrane that lies between them into a widespread transverse fold, which has been compared to the broad ligament in the female. In front of this the intervesiculovesical cul-de-sac progressively disappears with the years, but the deeper cul-de-sac behind, between the seminal vesicle and the rectum, persists (though in less pronounced form) down to old age, constituting the male Douglas's cul-de-sac. The common membrane forming the bed of the vesicles is composed of connective tissue and numerous elastic fibers, remarkable for their length. It encloses, in addition, a considerable number of smooth muscle fibers, both transverse and longitudinal. The latter form reddish bundles that are sometimes visible to the naked eye.

The tunica propria. The seminal vesicles and also the vasa and ejaculatory ducts are invested with a tunica composed of 3 layers: (1) an external fibrous layer, (2) a muscular layer, and (3) a mucous layer.

The fibrous layer is rather thin, and consists of bundles of very thick fibers, arranged concentrically without interruption by other tissues. It is easily differentiated from the loose vascular tissue that binds it to the bed of the vesicle, which is replete with vessels, mostly veins, and contains many nerve filaments.

The middle coat of muscular tissue is clearly differentiated from the external one and is the most important of the three, constituting about eight-tenths of the entire thickness of the total integuments of the vesicle. It is by reference to this coat that an essential difference is found between the integuments of the vas, with its ampulla, and the seminal vesicle itself, since in the vas and ampulla the muscular coat is well differentiated into three layers while only two exist in the corresponding coat of the vesicle. Of the two, the outer and thinner is formed of longitudinal fibers, while the inner and thicker consists of transverse or circular fibers. Only the longitudinal fibers continue down into the ejaculatory duct, becoming less and less in number as they approach their termination.

There is also a small muscular bundle that unites the prostatic utricle to these organs. According to Robin and Cadiat, who made a special study of this formation, it has its origin in the middle of the superior wall of the utricle, takes a backward direction as it traverses the elastic system of the verumontanum, passes out of the prostate, enlarging and spreading out as it goes; then, passing above the vasa, becomes inserted on the internal aspect of the vesicles. At its termination it accordingly forms two branches, diverging in an obtuse angle. This portion, according to the above authors, appears to be what Kölliker described as a " muscular ligament " which unites the two vesicles.

The mucous layer is of a striking grayish-white color and presents a reticulated appearance. Its internal surface is covered with many linear projections forming a network, with alveoli between, deeper than those of the gall-bladder; these are often subdivided into small cellules by secondary vegetations. They are largest in the lower portion of the vesicle; in the ejaculatory duct they are found only in the first quarter. It is these depressions that have been mistaken for glands of the mucous coat of the seminal vesicle. Microscopic examination reveals in this coat chiefly connective-tissue cells, with a considerable amount of elastic tissue which forms an almost continuous layer on the side adjoining the muscular coat, to which it is closely adherent, without interposition of cellular tissue. The reticulated appearance is seen, upon close inspection, to be due to vegetations which are observed to undergo hypertrophy under the influence of inflammation. In the fetus no reticulation exists. Their development is evidently related to the secretory function of the vesicles, of which they increase the active surface. Guelliot thinks that, as villosities, they may play a rôle of absorption, but he is convinced that they are not glands, for they have no proper wall and are lined with the same epithelium as the surrounding parts.

Blood vessels and lymphatics. The seminal vesicles receive their blood supply from the hypogastric artery through the intermediary of the median hemorrhoidal, the deferential, and the inferior vesical arteries, especially the last named, which, passing between the rectum and the bladder, spread out into a great number of branches destined to supply the bladder, vasa deferentia, prostate, and the seminal vesicles. One of these branches, penetrating the infundibulum of the prostate, follows the ejaculatory ducts to the prostatic utricle. According to Jarjavay, it is often double, in which case the posterior branch is the one charged with the supply of the seminal vesicles and the ejaculatory ducts. The principal vascular pedicle reaches the vesicles by this route at their base. A branch of the median hemorrhoidal enters the vesicle on its posterior aspect, its branches anastomosing with those of the deferential and the inferior vesical. The arterioles follow a sinuous course among the circumvolutions of the organ, then penetrate its outer coat, from which they pass into the muscular and mucous tunics.

The *venules* are difficult to recognize in the muscular tunic, but they become conspicuous in the fibrous coat, especially on its free surface, outside of which they form a veritable network which becomes the more marked as the subject increases in age. Gillette, who made a special study of this plexus, divided it into 3 secondary groups: (1) a superior group, formed of veins passing from one side of the vesicles to the other, anastomosing in full stream; (2) an anterior group, intermediate between the vesicles and the bladder, which receive the branchlets of the fundus of the bladder; and (3) a posterior group, communicating widely with the prostatic and hemorrhoidal plexus. It is here that phleboliths are most often found, such as are commonly seen in plain roentgenograms. All these veins unite to form the great vesicoprostatic plexus, which empties into the hypogastric vein.

The *lymphatics* of the seminal vesicles arise from two networks, one in the muscular and the other in the mucous tunic. A third network is formed from the former of these, which is spread over the surface of the vesicles, and out of this pass two or three efferents to some of the hypogastric nodes. It is a matter of great importance that there are frequent anastomoses between the efferent vessels from the prostate, seminal vesicles, and the wall of the bladder on the one hand, and the lymphatics of the ureter, pelvis, and kidney on the other hand; also that a common group of lymph nodes receives the drainage from all of these.

The nerves of the seminal vesicles. The seminal vesicles are supplied by the lumbar and abdominal sympathetic, and by the second and third pairs of lumbar nerves (Morat and Doyon), through the intermediary of the hypogastric plexus. Nerve branches arise on each side of the lower end of this plexus, at the level of what has been called by Valentin the vesicohemorrhoidal ganglionic layer; these pass to the external border of the vesicle, where they anastomose in a rich plexus covering both the anterior and posterior surfaces of the organ. This network in its turn intercommunicates with the hemorrhoidal, vesical, and prostatic plexuses, from which are derived the branches which innervate the lower part of the vesicles.

According to Sappey, the nerve branches penetrate the fibrous tunic, where they are very numerous. This author claimed to have been able to follow them into the muscularis, where they were lost to view, their terminations remaining unknown.

Giesser, in 1866, watched the movements of the ejaculatory ducts and the seminal vesicles, and established the ejaculatory action of fibers of the sympathetic coming from the inferior mesenteric ganglion.

Five efferent branches of the hypogastric plexus were recognized by Latarjet and Bonnet, as follows:

(1) A branch supplying the bladder and ureter.

(2) A smaller branch likewise supplying these organs.

(3) A branch supplying the lateral surface of the bladder and the external surface of the seminal vesicles.

(4) A branch, the largest of all, which crosses the external surface of the upper end of the corresponding seminal vesicle.

(5) A branch innervating the prostate.

Anastomoses occur between all these nerves, resulting in an extremely close network of nerve branchlets uniting the organs which they supply. Thus, the branches of the hypogastric ganglion, which pass to the seminal vesicles, anastomose with branches of the nerves of the vasa deferentia, of the ampullæ, the ejaculatory ducts, and the prostate, creating a common nerve supply to the entire spermatic tract.

THE ANATOMY OF THE ADNEXA

The structure of the vas deferens and ampulla. The vasa are invested, like the seminal vesicles, with 3 coats; (1) a fibrous, (2) a muscular, and (3) a mucous. The tunica mucosa, of the same whitish color as that of the vesicle, is characterized by longitudinal folds which become obliterated when the vas is distended. It is separated from the tunica muscularis by a sort of submucosa, very rich in elastic fibers. In the ampulla, the modifications undergone by the mucosa are of an important character. First, it becomes thicker, and second, its color changes from white to yellowish or dark gray. In addition, it presents a number of folds, more or less elevated, which anastomose with one another to form the most various angles, giving the interior a finely reticulated and alveolar appearance. Between the folds are found depressions and alveoli very variable in surface and depth, until the entire ampulla is subdivided into honeycomb compartments of the same type as those of the seminal vesicle.

The dimensions of the vas deferens and ampulla. Each vas has a total length of 35 to 45 cm., and an average diameter of 2 to 2.5 mm. in its lower and median portions, which are regular and cylindrical in shape, like other tubular structures; but as it approaches the seminal vesicle and broadens out into the ampulla, it reaches three or even four times its earlier normal dimensions and assumes many of the characteristics of the seminal vesicle itself. In fact, after surgical removal of the vesicle, the ampulla has sometimes been known to replace the missing organ by more or less completely adapting its structure to the need created, and at the same time undergoing a compensatory hypertrophy. Previous to the point where it expands into an ampulla, the vas is of a peculiarly solid and characteristic consistency, due to the striking thickness of its walls, which makes it easy for the surgeon to distinguish it from the surrounding tissues and thus to establish its exact position and anatomical relations.

The vessel and nerve supply of the vas deferens. The arteries of the vas deferens come from the deferential artery, which is a branch of the vesical artery. During its course it subdivides into many arterioles, which form in the tunica fibrosa a first network, then subdivide further into the capillaries of the muscularis and mucosa. The veins originating in these capillaries take their course into the tunica fibrosa, or, like the arteries, form a superficial network which furnishes numerous branches for the spermatic cord and the seminal and vesicoprostatic plexuses. The nerve supply of the vasa comes from the hypogastric plexus, which furnishes both vasa with an abundance of superficial nerve fibers, and also sends fibers into the interior of the vas, forming plexuses destined for the muscularis and mucosa.

TOPOGRAPHICAL RELATIONS

Topographical relations of the seminal vesicles. The anterior aspect of the seminal vesicle lies in close relation to the base of the bladder, from which it is separated by only a thin layer of connective tissue. The part of the bladder wall with which it is most intimately associated corresponds approximately to the trigone of Lieutaud when the vesicle is of normal size. Vesicles of abnormal length, however, overtop this region of the bladder. Between the vesicle and the bladder passes the terminal portion of the ureter for a tract of about 1½ cm., through the intermediate connective tissue separating the vesicle from the bladder. It is easy to see how readily infection may pass from vesicle to bladder in the event of abscess or fistula formation following inflammatory conditions of the former.

The posterior aspect of the seminal vesicle faces the antero-lateral portion of the wall of the rectum, from which it is separated by a loose mass of connective tissue and fat. Denonvilliers in 1837 called attention to a kind of serous bursa at this point behind the vesicles and in front of the rectum, measuring 3 to 4 cm. in length and filled with a citrine serous fluid. This has accordingly been called Denonvilliers' fascia, or Denonvilliers' aponeurosis.

Denonvilliers' aponeurosis. This very important and distinct enveloping structure, which, by completely surrounding and enclosing the seminal vesicles and ampullæ, serves as a protecting sheath for these organs, has been described by Denonvilliers as follows: On the two sides it becomes merged with the close fibrous tissue which surrounds the venous plexuses of the base of the bladder; on its anterior border it becomes lost on the lowermost extremity of the prostate; at its lower margin it adheres to that portion of the peritoneum which descends between the bladder and the rectum, with an adhesion as intimate as if it were actually fused into that tissue, which explains the constancy of the retrovesical cul-de-sac of the peritoneum; the crescent form of this cul-de-sac becomes blended with the disposition of the aponeurosis, which invariably describes a curve with its convexity facing anteriorly, or else a V with its angle open toward the front. The lower aspect, which touches the rectum, barely adheres to the latter by a very loose fibrous tissue; but from the upper aspect there arise very dense fibrous prolongations which envelop the seminal vesicles. The texture of this aponeurosis resembles that of the dartos: it appears to be composed chiefly of fibrils which at their start radiate outward from the posterior portion, the most pronounced of which are those occupying the median line. In vigorous young subjects, muscular fibers manifestly exist, but only on the sides. This prostatoperitoneal aponeurosis is very resistant, and forms, with the base of the bladder, a kind of compartment closed on all sides, in which are included the seminal vesicles and a part of the ureters and of the vasa deferentia. The latter structures pass into this cavity through the midst of the very dense tissue which forms its lateral walls.

This fascial envelop, covering the seminal vesicles, has also been described by Lowsley in his embryologic study of the human prostate gland.

The importance of this glistening structure as a landmark in perineal operations, particularly in surgical procedures on the prostate and seminal vesicles, is recognized by all surgeons. With only this fascia and loose connective tissue between the vesicles and the rectum, the exploration of the vesicles by the rectal touch becomes very feasible.

Contact with the peritoneum. The most important of all the relations which the seminal vesicles present is this contact with the peritoneum. It is immediate and intimate, so close that it readily accounts for the frequency with which the inflammation, in a simple vesiculitis, spreads to the abdominal serosa, where it may under some circumstances even produce a fatal peritonitis.

As Guelliot points out, the peritoneum does not completely surround the base of the seminal vesicle. It caps it, so to say, then encroaches upon its posterior aspect and descends more or less on to the vas deferens; but in front the margin of the vesicles corresponds, without intervening tissue, to the external aspect of the vesical trigone and to the ureteral orifice into the bladder. The serosa, after having invested a part of the vesicle and a considerable tract of the vas, descends into the space lying between the two vasa; then, becoming reflected, climbs again over the rectum, forming a transverse fold upon which is inserted the aponeurosis of Denonvilliers.

The intervesicular triangle. This arrangement results in the formation of an isosceles triangle, known as the *intervesicular tri-*

angle, having the prostate below for its apex, the peritoneum above for its base, and the two vasa for its sides. This triangular space is of great clinical significance, since many pathological lesions may arise from this area, as we shall see later in the chapter on surgical pathology.

The internal aspect of the seminal vesicles is thus in close relation to the vasa deferentia, which at this point in their course become considerably expanded and are known as the ampullæ of the vasa. So close is the union between the ampulla and the vesicle that they appear almost as a single structure until dissected. Between the two ampullæ, which lie pressed laterally against the vesicles in an oblique line directed downward and inward, lies the intervesicular triangle, its sides being formed by the ampullæ of the vasa, which, after coming up from the testes below, pass around the top of the vesicles and then converge downward and inward toward the median line on their way to the ejaculatory ducts.

The external aspect of the seminal vesicle is in contact with a rich supply of vessels forming a venous plexus, which must be taken into account in every operative approach to the vesicle. On this aspect the organ takes a very oblique direction as a rule, but may in some cases be found horizontal, its more internal median portion resting upon the shoulders of the prostate.

The upper extremity, or base, of the vesicle corresponds with the lower end of the ureter, which approaches it on its superolateral wall. The two structures are in such intimate relation that inflammatory processes may easily spread from the vesicle to the ureter in cases accompanied by perivesiculitis, or from the ureter to the vesicle when there is a stone impacted in the intramural portion of the ureter, causing spermatic colic. In performing vesiculectomy the surgeon must always bear in mind the closeness of the ureter, which crosses the vas deferens only a few centimeters above the base of the seminal vesicle.

The lower extremity, or summit. The summit of the vesicle, also known as its neck, is prolonged into a tapering point where it meets in a very acute angle the lower part of the vas, below which junction it is called the ejaculatory duct. Externally it is adherent to the lower part of the base of the prostate; internally it approaches its mate from the other side and enters the prostate, where it emerges into the prostatic urethra through a small opening upon the verumontanum, external to the prostatic utricle.

Topographical relations of the vermontanum. The upper rounded extremity of the verumontanum gives rise to one or more folds running backward, which, together with a number of bands, attach the structure to the vesical orifice of the urethra. These folds may be prominently developed, insignificant, or wanting altogether. When they are absent, a more or less marked depression is observed behind the verumontanum, which is known as the prostatic fossette, and into which the prostatic ducts of the median lobe open. The base of the verumontanum merges into the ure-

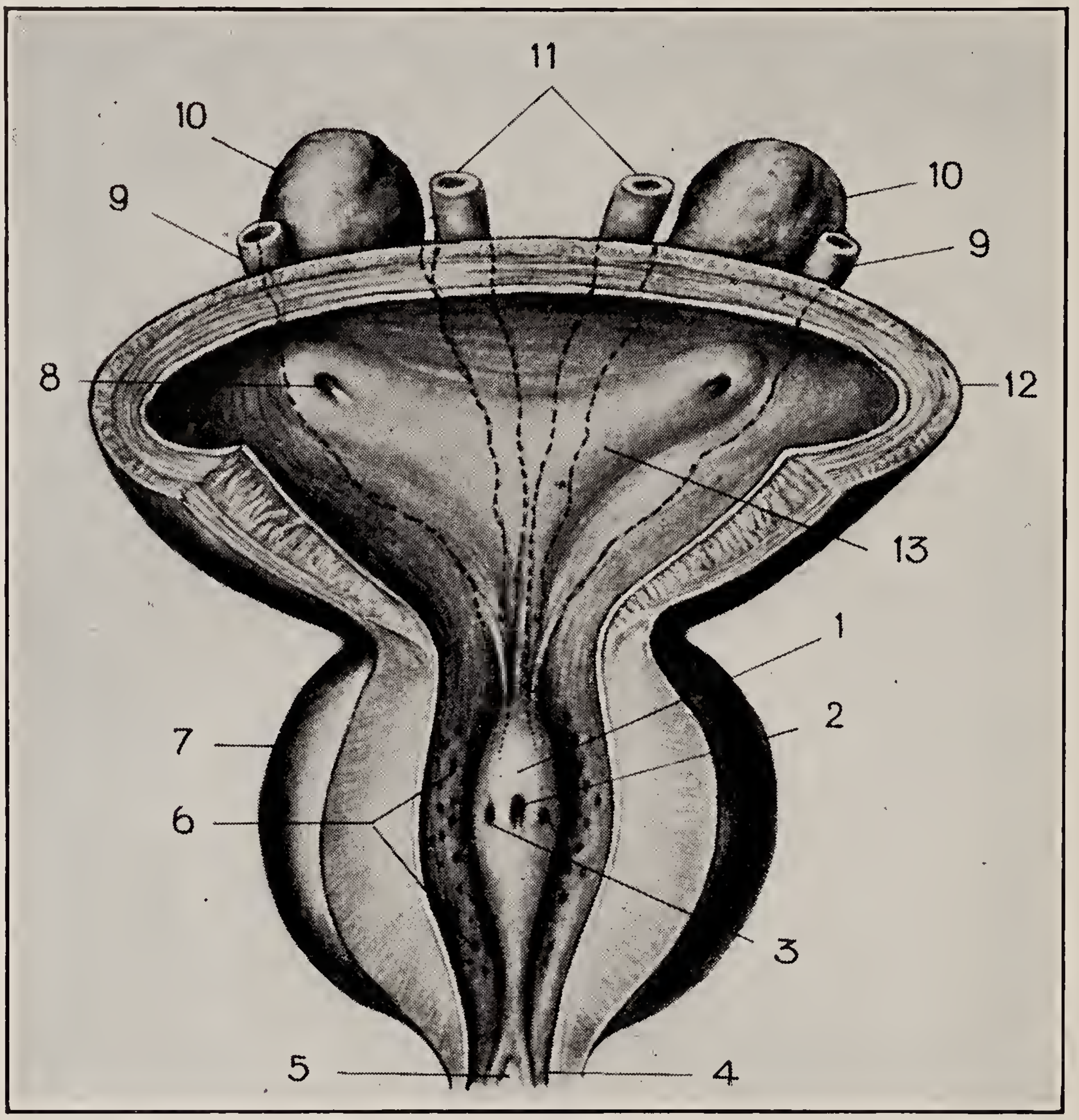

Fig. 7. Frontal view showing the topographical relation of the verumontanum and ejaculatory ducts to the urethra, prostate, and bladder. Observe the close relationship of the seminal vesicles and ampullæ to the trigone and ureters.

1. Verumontanum.
2. Opening of the utriculus prostaticus.
3. Opening of the ejaculatory ducts.
4. Urethra.
5. Crest of the verumontanum.
6. Opening of the prostatic ducts.
7. Prostate.
8. Opening of the ureteral orifice.
9. Ureter.
10. Seminal vesicles.
11. Ampullæ.
13. Trigone.

(Modified drawing from Testut: *Anatomy*.)

thral wall upon which it rests. Its summit, entirely free within the urethral cavity, presents an anteroposterior cleft, which constitutes the urethral end of the prostatic utricle. (See Fig. 7.) At the right and left of this summit, and sometimes so small as to be scarcely visible, are the minute orifices of the ejaculatory ducts, which throw the semen into the urethra at the moment of ejaculation. On each side of the verumontanum is a fossa running in an anteroposterior direction, into which open the principal prostatic ducts, the openings of which are known as the posterior glandular orifices. Smaller orifices of the same kind are observed on the anterior and lateral walls of the urethra facing the verumontanum. Also somewhat posterior to the verumontanum, and at the level of the floor of the vesical orifice, are found the minute structures known as Albarran's glands, which, when hypertrophied, constitute the much-discussed median lobe or bar of the prostate. A little in front of the verumontanum, and approximately at the level of the apex of the prostate and the beginning of the membranous urethra, lie the two openings of the ducts from Cowper's glands.

According to Hawkins, the verumontanum and its contents — namely, the utricle and the ejaculatory ducts — are not properly a part of the prostate, but have a distinct wall of their own and lie outside the true capsule of the prostate.

Topographical relations of the ejaculatory ducts. The ejaculatory duct, which is 2 to 3 mm. wide and slightly sacculated at its origin, where the ampulla and vesicle meet to constitute this tubular organ, contracts to 0.3 mm. as it proceeds downward in its course, and does not exceed 0.5 mm. in diameter at its termination in the verumontanum. Taking a course downward and inward, it penetrates the base of the prostate, where it comes into close relations with the cellular tissue, arteries, veins, and muscle fibers passing to the vesicle from the prostatic utricle. Its length, from the vesicle to the verumontanum, varies from 15 to 22 mm. As it enters the prostate, it opens out slightly to form a small lozenge-shaped structure, known as the *ejaculatory sinus*, approximately 4 mm. long and 3 mm. wide at its equator; but it contracts again at its lower pole, this time to 0.2 mm., below which point it maintains an approximately uniform caliber, but turns slightly upon its axis before entering the verumontanum through what Virchow described as a veritable valve. Recent research has shown that the ducts are at first parallel to one another during their course through the prostate, then converge for 1 or 2 mm., only to diverge again for a distance of 1 to 1.5 mm. as they debouch into the verumontanum, at the right and left respectively of the prostatic utricle, from which they are nearly always separated by venules. Before perforating the urethral mucosa, the ducts pass along under it and come out through elongated orifices, in the shape of antero-posterior slits, — an arrangement that serves to prevent the reflux of fluid in the urethra into the vesicles. In cases where the prostatic utricle does not exist, all that separates the two ducts is fibrous and elastic tissue, and, in rare cases, a small amount of prostatic substance, according to Robin and Cadiat.

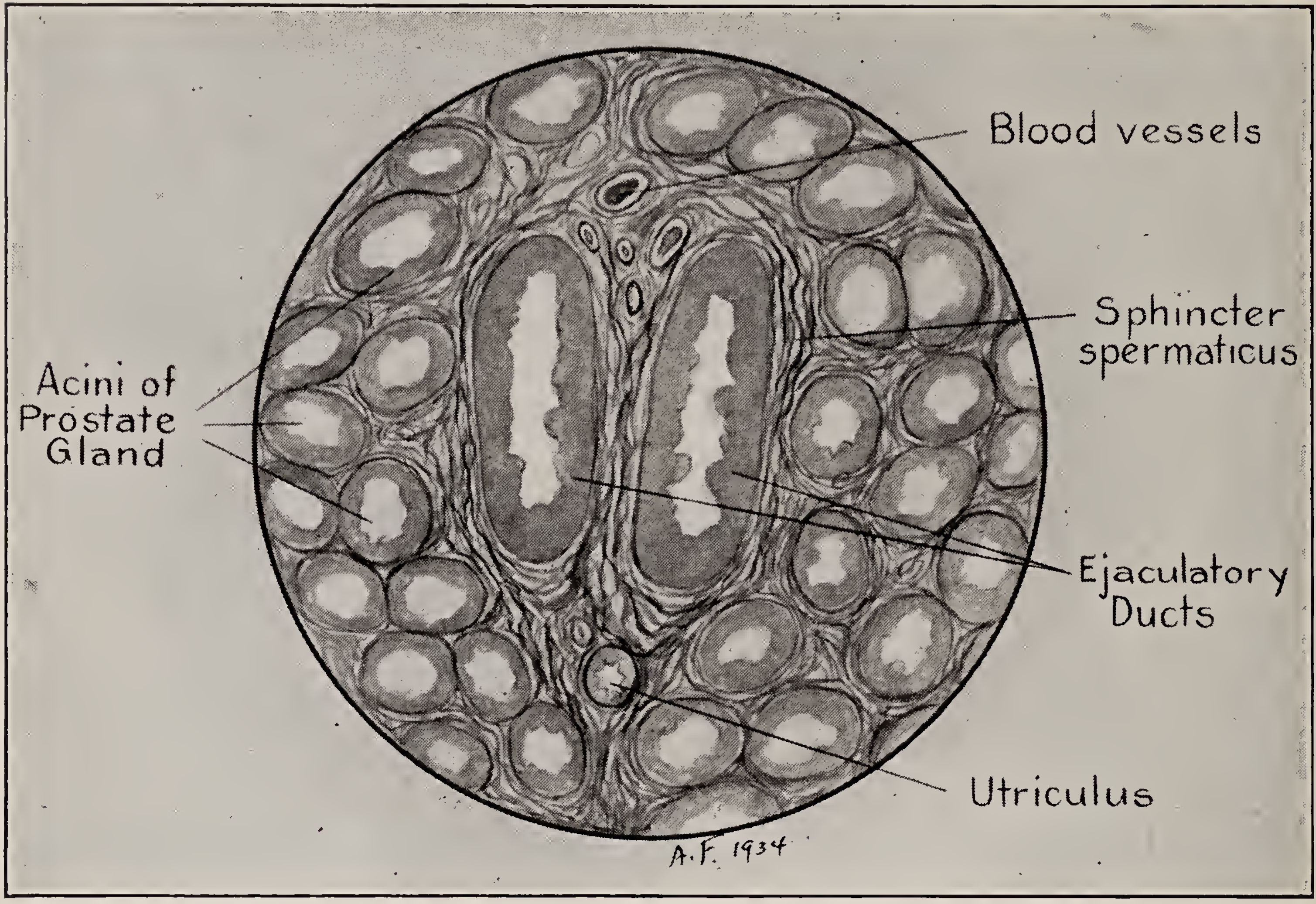

FIG. 8. Microscopic sagittal section of the verumontanum, showing the ejaculatory ducts enveloped by their sphincters and by the spermatic muscles, which separate these structures from the prostate gland.

Note the independence of the utriculus prostaticus from the ejaculatory ducts, prostatic acini and blood vessels. (Modified drawing from B. A. Thomas after Porosz.)

The ejaculatory ducts traverse the prostate independently of the prostatic acini and of one another, each being surrounded by a circular lamellar tissue, which serves as a sphincter, and to which the name *sphincter spermaticus* has been given. Anatomically the

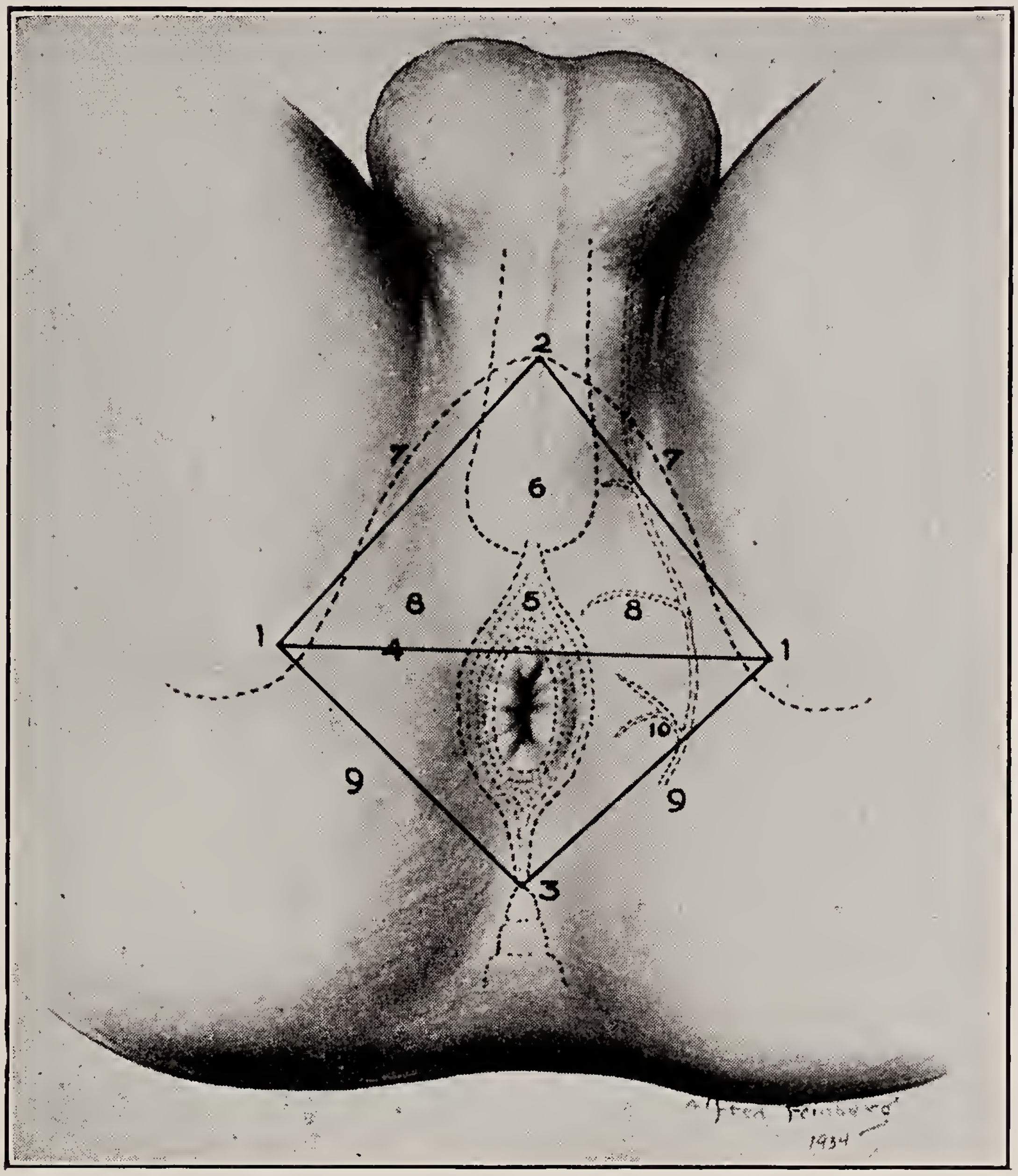

FIG. 9. Surgical topography of male perineum, showing the perineal rhomboid and its two triangles, which constitute the surgical landmarks of the region.

1. Right and left tuberosities of the ischia.
2. Angle of the pubis at the bulb.
3. Tip of the coccyx.
4. Line joining the two tuberosities of the ischia, corresponding to the line of union where the deep layer of the superficial fascia meets the base of the triangular ligament.
5. Central point of perineum, coinciding with the anal sphincter.
6. Bulb of the urethra, in the central tendon, which unites it to the anal sphincter.
7. Right and left rami of the ischia and pubis.
8. Right and left ischiorectal fossæ.
9. Margin of right and left gluteus maximus muscles.
10. Left internal pudic artery, giving off its inferior hemorrhoidal branches and its superficial perineal and other branches to the superficial muscles of the perineum and the bulb of the urethra.

ejaculatory ducts and the prostatic utricle are three independent tubes. Topographically these three tubes, passing through the prostate to open on the verumontanum, are intimately related, but they never merge except in cases of anomaly. The ejaculatory ducts have their own proper blood, lymphatic, and nerve supplies. The blood vessels traverse the muscular tissue separating the two ducts as well as that lying between them and the utricle. (See Fig. 8.)

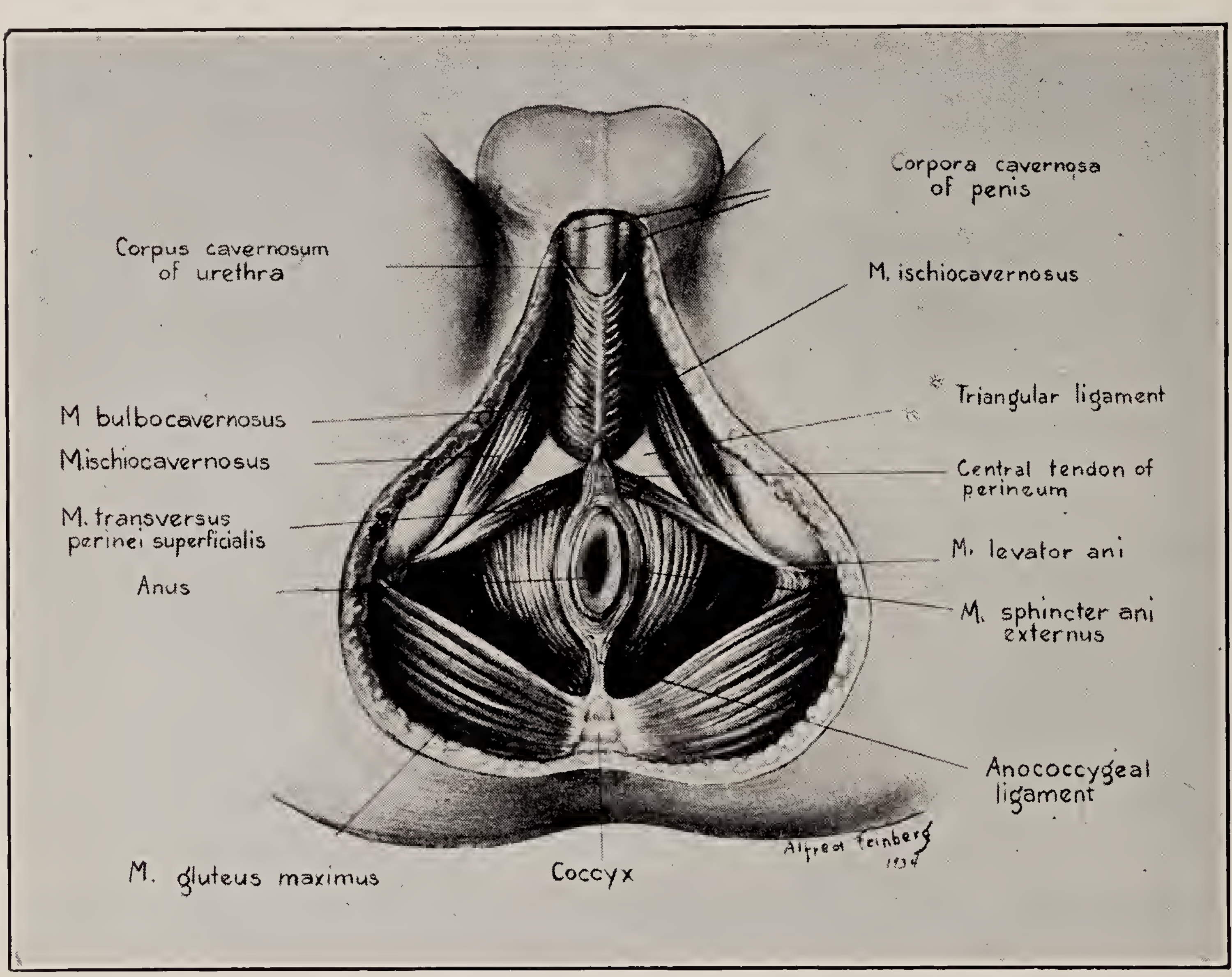

FIG. 10. Dissection of the superficial muscles of the perineum.

Surgical topography of the male perineum. In the surgical anatomy of the seminal vesicles and prostate, as well as in that of the urinary bladder and urethra, the male perineum occupies a very strategic position, with its complex anatomical structure of muscles, fasciæ, and aponeuroses, a clear knowledge of the interrelations of which is of vital importance in any operation to be performed on these organs by this route of approach.

In view of the great number of operations performed at the present time by the perineal route, such as prostatectomy and vesiculectomy, it is obvious that a general description of this anatomical region is pertinent at this point.

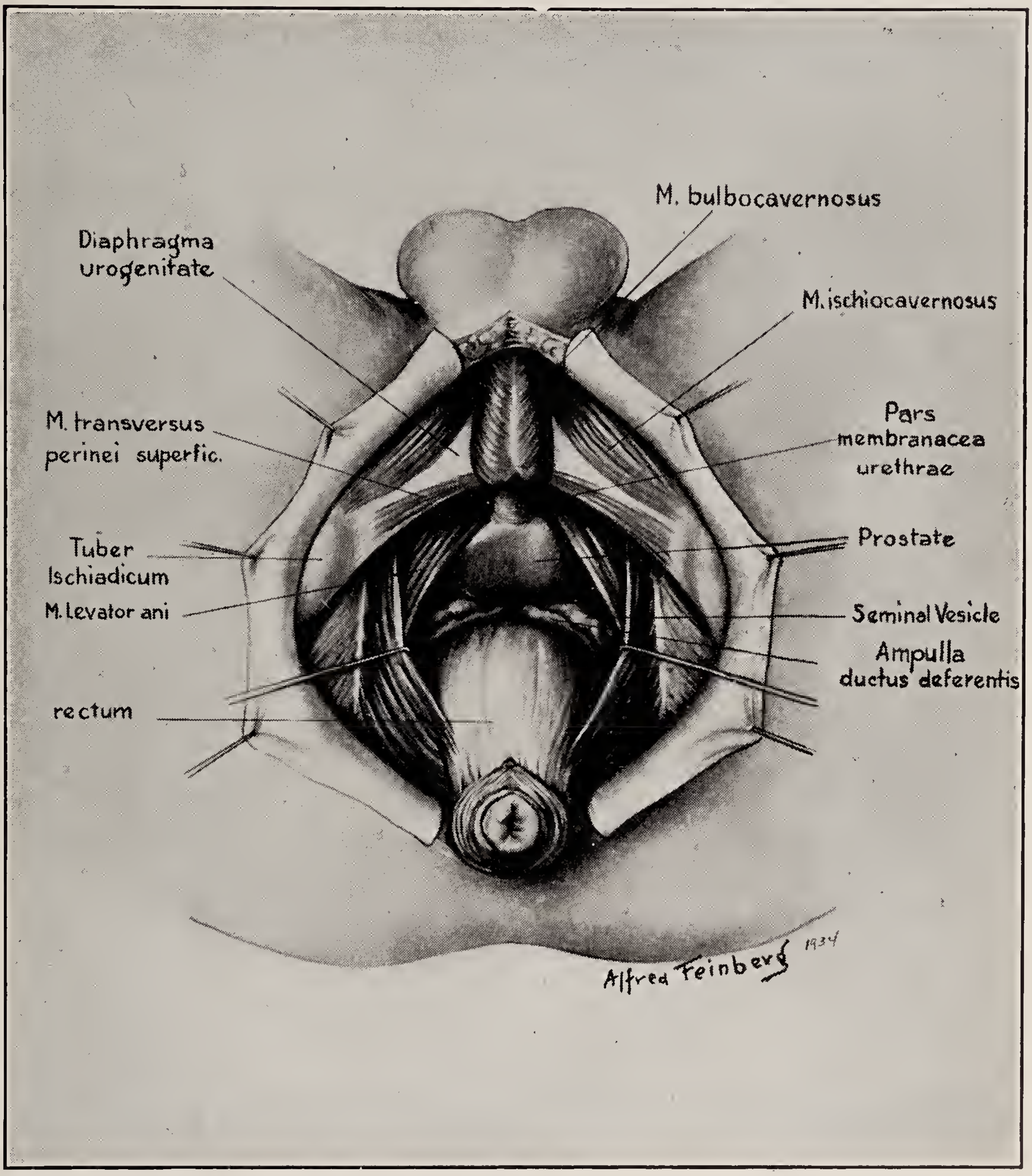

FIG. 11. Dissection of the deep perineum, showing the relationship between the surface of the prostate, the seminal vesicles, ampullæ, and vasa deferentia. The central tendon and recto-urethralis muscles have been divided, the bulb retracted to expose the membranous urethra, and the rectum pulled backward, giving ample room for surgical approach to the prostate and seminal vesicles.

The perineal rhomboid. With the patient in the exaggerated lithotomy position, the perineum, which is the floor of the pelvis, may be regarded as a rhomboid, the vertical diameter of which runs from the angle of the pubis in front to the tip of the coccyx behind, while the transverse diameter connects the two ischial tuberosities (Fig. 9). The transverse diameter accordingly divides the perineal region into two triangles, an anterior or urogenital, and a posterior or anococcygeal. Since it corresponds to the line of union where the deep layer of the superficial fascia meets the base of the triangular ligament, it divides the perineum into two entirely separate compartments.

A knowledge of this line is of great surgical importance, since, in the event of a rupture of the bulbous or membranous urethra, occurring during the course of an operation, the urine is prevented from escaping backward beyond this partition and must find its way out anteriorly, passing to the abdominal wall or to the scrotum, where it may, if septic, result in abscesses or other inflammatory complications of these regions.

The anterior perineum. For surgical convenience, the anterior perineum may again be divided into two parts, the *superficial* and the *deep* perineum, in order that, in the dissection carried out during the course of an operation, we may be able to follow the line of cleavage that unites or separates these structures.

(1) The superficial perineum. In the superficial elements of the perineum, in addition to the skin, fasciæ, cellular tissue, and blood supply, it is important to recognize the bulb of the urethra, which is located at the top of the upper triangle, and the central tendon, or anobulbar raphe, which unites the bulb to the anal sphincter. On each side of this is the corresponding triangular ischiorectal fossa. We also identify the superficial transverse perineal muscle and the ischiocavernosus and bulbocavernosus muscles at each side (Fig. 10).

In the further dissection, extreme care must be taken not to injure the bulb, since this may cause annoying bleeding, but to recognize and cut the raphe at the point of the central tendon in order to separate the bulb from its attachment and bring us to the deeper structures of the perineum.

(2) The deep perineum. When, in the anatomical dissection, the central tendon has been divided and retracted, and the bulb retracted upward, we readily fall into the recto-urethralis muscle which constitutes part of the central tendon and which attaches the rectal wall to the membranous urethra, some of its fibers passing to the fascia that covers the prostate gland. On each side is the corresponding levator ani muscle; these are gently separated from one another in order to bring to view the glistening fascia of Denonvilliers, or the so-called prostatoperitoneal aponeurosis which envelops the prostate and the seminal vesicles as well. Proceeding by blunt dissection, the remaining fibers of the recto-urethralis muscle are now separated, with proper retraction of the bulb and the rectum (Fig. 11).

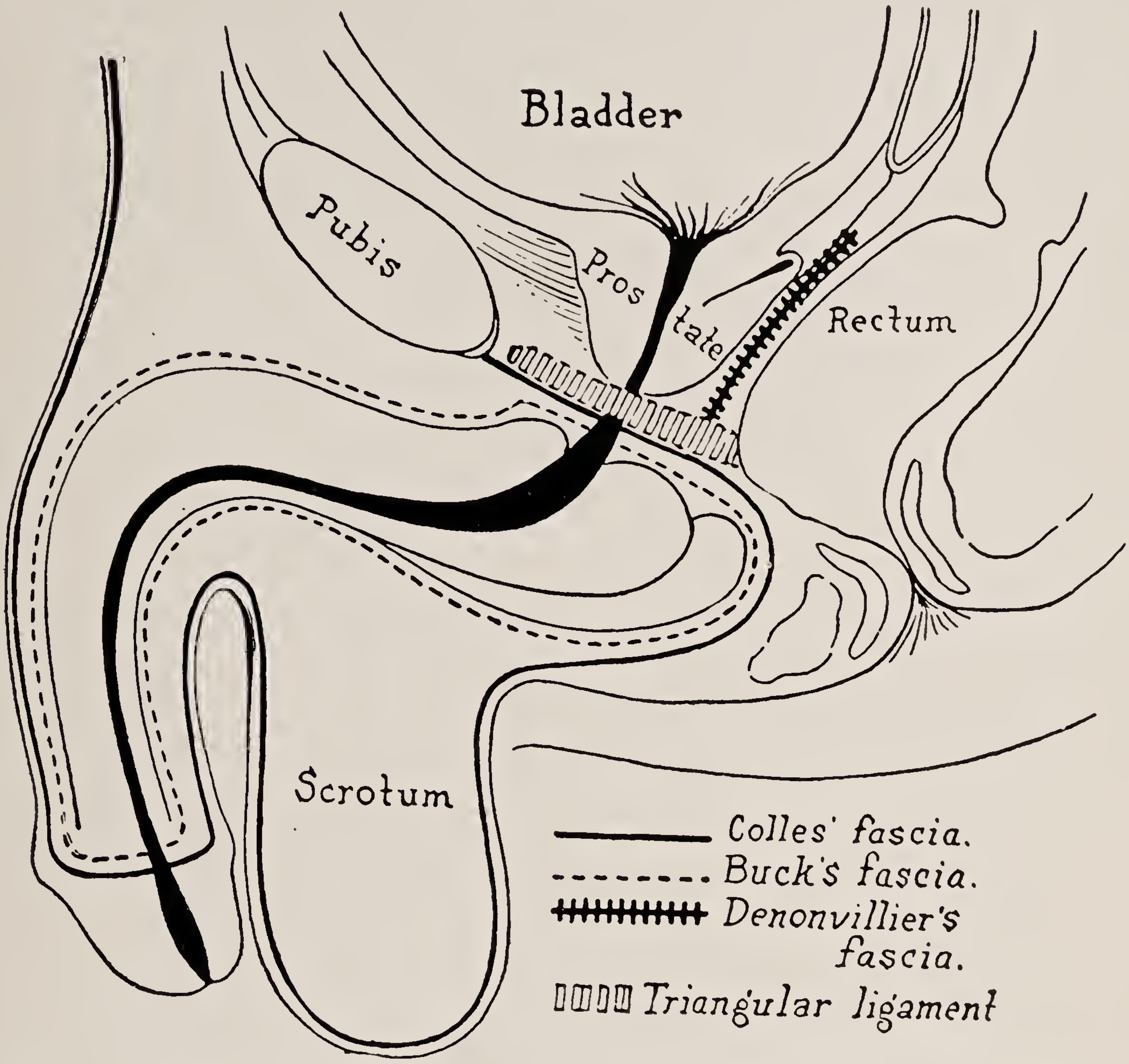

FIG. 12. Diagram of Colles', Buck's and Denonvilliers' fasciæ in relation to the genito-urinary organs of the male. (Courtesy of Dr. M. B. Wesson.)

The intimate surgical relationship between these anatomical structures can now be readily recognized: at the top the bulb, then the membranous urethra at the apex of the prostate, Denonvilliers' aponeurosis covering the latter, and at its base, on each side, the union of the ampulla and the corresponding seminal vesicle into one common duct to traverse the prostate, while at the bottom, and well retracted, is the rectum. This viscus must be well protected in any surgical procedure of the perineum in order to prevent rectal fistula or other injury during operation.

The supporting lines of the perineum, in addition to the triangular ligament and the perineal muscles, are the various layers of fascia of the region, represented by the superficial, median, and deep aponeuroses (to which the names of Colles', Buck's, and Denonvilliers' fascia, respectively, have been given) as well as by the deeper aponeuroses of the pelvis which extend to its entire floor. (See Fig. 12.)

The posterior perineum, or anococcygeal region, will not be described here, because of its limited usefulness as an avenue of approach to the prostate and seminal vesicles.

The blood supply. In operating upon the perineum, the surgeon must take care not to cut into the main blood supply of the perineum, observing special caution in avoiding possible injury to the internal pudic arteries and the many vesical and visceral branches of the middle hemorrhoidal arteries.

The testes and epididymes. Although the testes and epididymes are properly a part of the spermatic tract, these organs will not be discussed here since the study of their surgical aspect has been fully covered elsewhere in this publication by another author.

CHAPTER V

PHYSIOLOGY OF THE SEMINAL VESICLES, AMPULLÆ, AND VASA DEFERENTIA

Principal physiological functions. The seminal vesicles have two principal physiological functions: (1) they serve as reservoirs for the semen, and (2) they modify, by a glandular secretion, the liquid which is stored within them.

There is a striking analogy between the seminal vesicles and the gall-bladder. Just as the latter (which is merely an appendage) stores the bile secreted by the liver, so do the vesicles store the seminal secretion of the testes until such time as it is required for coitus.

We have already seen that the early anatomists recognized the seminal vesicles only as storehouses or reservoirs, and that when the first proponents of the secretory office of these little organs appeared, they tried to discard the old view, of which de Graaf (1668) was the special champion, and to substitute a purely glandular theory of their function. Thus, instead of admitting that these organs might easily perform a twofold function, Swammerdam and Van Hoorne preferred to see in them only secretory glands, totally unrelated to the vasa deferentia.

Today, however, it is completely established that the seminal vesicles serve both to store the semen for later use and also to enrich it with their own special secretory product.

The vesicles as reservoirs. Two irrefutable proofs exist, according to Guelliot, that the vesicles are reservoirs for the semen. First, they always contain living spermatozoa (except under the anomalous condition of azoospermia due to testicular lesions or to general constitutional disease) during the genital period of the individual's life. " Since these are not formed on the spot," says Guelliot, " they must certainly have come from the vasa deferentia." Secondly, if the vas of a cadaver is injected with air, water, or mercury, it is observed that the vesicle always becomes distended before a bubble of air or a drop of liquid appears in the urethra. This experiment was first made by de Graaf, who, after injection of the vas, saw the fluid spurt out through the ejaculatory duct like a small fountain as soon as the vas was filled up.

When the vesicle becomes diseased or obliterated, or is excised surgically, the fact that the ampulla (which has the same anatomical disposition and histological structure as the seminal vesicle) gradually becomes distended by its normal physiological process and finally takes over the function of the vesicle, becoming itself the reservoir of the semen and possessed of the same power of expulsion during ejaculation, is a further proof that the seminal vesicle under normal conditions fulfils this demand for a storehouse.

The question naturally arises as to why the semen should be required to travel over this long and circuitous course instead of passing directly into the urethra.

Constricting action of the ejaculatory ducts. Many investigators have suggested that there might be a sphincter at the level of the ejaculatory duct, but no such structure has ever been discovered, beyond the presence at this point of a few longitudinal fibers which are obviously incapable of closing this channel. It is more probable that the retraction of the numerous elastic fibers which form a veritable sheath around the duct, assisted by the pressure of the surrounding portions of the prostate, is sufficient to prevent the passage of the seminal fluid. This would explain why, even in the cadaver, where muscles are relaxed, the substance injected through the vas deferens completely fills the seminal vesicle before it is able to overcome the resistance of the ejaculatory duct. If the verumontanum is abraded and a few millimeters of the end of the ejaculatory duct removed, the injected fluid still distends the reservoir before it gushes out over the cut surface, proving that the constricting action is not limited to the urethral orifice of the ejaculatory ducts but is distributed over a great part of their length.

The glandular rôle of the vesicles. The glandular nature of the seminal vesicles has been equally confirmed by numerous authors, among the earliest being Cabrol (1594) and Riolan (1618). Cabrol reported that in dissecting the cadaver of a soldier who had been hanged for violating a young girl he found that the man had no trace of any testes, but that his seminal vesicles, to the astonishment of all present, were as full of semen as those of any man whose cadaver Cabrol had since dissected.

Several early writers, however, such as Van Hoorne, Swammerdam, Wharton, Harder, Taury and others, erroneously described the vesicles as simple glands annexed to the terminal part of the spermatic tract. A study of their mucosa reveals that they have no glands other than such as are present in all mucosæ. To determine the special character of the secretion of this vesicular mucosa is not altogether easy, since the vesicular secretion is always mixed with that coming from the testis and vas deferens. To obtain such a secretion unmixed, one would have to have recourse to the seminal vesicles of a subject born without testes or of one who had been castrated for a considerable length of time.

According to Luys, the glandular rôle of the vesicles is clearly demonstrated by the existence within their mucosa of granulations, plasmosomes, rodlike bodies, and vacuoles, as described by De Bonis (1909). Luys also points out that in cases where there has been unilateral castration the seminal vesicle still retains its normal size, and that instances have been observed in which, owing to a structural anomaly, the seminal vesicle was completely separated from the vas deferens and opened directly into the verumontanum, where it could not be a reservoir.

Characteristics of the seminal secretion. In a study of the characteristics of the mixed secretion obtained from the seminal vesicles in the cadaver, as compared with the secretion obtained directly from the testes, Guelliot found that the semen from the vesicles is usually of grayish color, sometimes a little dark, never entirely white, and that it grows darker the longer the time intervening since death. Its consistency is very variable: sometimes creamy, sometimes gelatinous (where mucus is very abundant) or, again, it may be granular. Thirty-six hours after death it becomes thinner, and finally liquefies. It is normally denser than water, and is slightly alkaline. In cases more numerous than is commonly believed, according to Luys, a phosphaturia that might be attributed to a renal origin is, in reality, due solely to the alkalinity of the vesicular fluid which has accumulated in the prostatic fossette. This fluid in a fresh state has no odor, but when stale takes on a urinous or fecal odor.

An average ejaculation has been estimated to weigh from 0.75 to 6 or 7 grams, varying with the age of the subject and the number of coitions. Upon expressing the vesicular fluid from its reservoir and measuring the amount, the capacity of a single vesicle has been found to average 1.5 to 2.5 cc., or roughly 4 cc. for the two organs. By mechanical dilatation the capacity of a single vesicle can be increased to 5 cc. or even 7 cc. Before puberty the amount of vesicular fluid is very small, and its consistency is serous; in some aged men the amount is great enough to distend the vesicles, while in others it is entirely wanting.

Presence of spermatozoa in the vesicles. Spermatozoa exist in the seminal vesicles of every male who has reached the age of puberty, and according to Robin and Cadiat they have been found still alive 82 hours after death in the vesicles of executed criminals. In addition, the vesicular fluid contains leukocytes, epithelial cells, and certain minute transparent concretions called by Robin *sympexions*, which he regarded as nitrogenous bodies due to the passage into the solid state of noncrystallizable principles of nitrogenous nature. These are found already in boys of 10 or 12 years, and they still exist in old men. Their diameter varies from $\frac{1}{100}$ mm. to 1 or 2 mm. Robin thought they commonly formed whenever the subject had been four or five days without coitus.

The vesicular fluid also contains mucus which mixes with the testicular fluid and renders it thicker. When the vas is obliterated it is this mucus that, almost solely, fills up the seminal vesicle. It is probable that the mucus possesses a considerable capacity for absorption, to judge from the great number of lymphatics and veins belonging to the vesicle and the villosities of its internal surface. This view has been held from ancient times, and has been supported by such modern writers as Haller, Exner, Königstein, Fürbringer, Meckel, and Nicloux. That toxins may be regularly absorbed from the vesicles when these organs are in a state of inflammation was first suggested by Young (1913), and this view is now generally accepted.

Physiological properties of the vesicular fluid. The physiological properties of the vesicular fluid are chiefly: (1) the dilution of the semen, (2) the nutrition of the spermatozoa, and (3) the coagulation of the semen as soon as it is mixed with prostatic secretion.

(1) The mass of spermatozoa arriving in the seminal vesicle from the ampulla of the vas deferens is too thick for ready progression through the small ejaculatory ducts, and requires dilution. This is accomplished by the secretion of the vesicle, which is mixed with the semen coming from the testes.

(2) Limon observed that when the spermatozoa issue from the canals of the testis, they are very poor in protoplasm, and that such protoplasm as a spermatozoon possesses is for the most part differentiated into an organ of movement to conduct it on its long

journey, which is made at the expense of its nutrition. In the economy of nature, therefore, provision is made for its reconditioning within the seminal vesicle, where it finds itself in a milieu containing suitable material to sustain it on its further journey. This material is in the form of various products thrown off by the epithelium of the vesicular portion of the spermatic tract.

(3) It has been shown by Camus and Gley that when the vesicular fluid meets the prostatic secretion, a ferment, to which the name *vesiculase* has been given, is elaborated, which causes it to coagulate into a white mass of the consistency of wax that will prevent the sperm from escaping from the vagina. Thomson-Walker observed this phenomenon in experiments upon rats and concluded that the same thing occurs in human beings.

The process of ejaculation. The rôle of the seminal vesicles in producing ejaculation has been divided into two separate processes: first, the passing of the semen from the excretory ducts into the urethra, and second, the expulsion of the semen from the urethra.

Expulsion of semen from the seminal vesicles. The expulsion of the semen from the seminal vesicles is dependent upon the smooth muscle fibers that enter into the structure of the vesicles and the vasa deferentia. According to Fick, Loeb and others, the contraction of these fibers is produced under the influence of the excitation of the motor roots of the second and third pairs of lumbar nerves which pass from that point into the chain of the sympathetic, through the inferior mesenteric ganglion, from which the impulse is transmitted by way of the hypogastric nerve to the seminal vesicle. The contraction is slow and progressive but energetic, propelling the content of the vesicle through the ejaculatory duct into the urethra with sufficient force to cause painful spasm in case any obstruction is present in the duct. Kölliker observed these peristaltic contractions *de visu* in an executed criminal a few minutes after death. They are attended by a contraction of the vesical sphincter, which closes the orifice of the bladder, and also by a contraction of the external sphincter ani and of the levator ani. To reach the urethra the semen must, of course, find the ejaculatory ducts patent, and it is also a prerequisite that there must be no reflux into the vasa deferentia. The extremely acute angle at which the ampulla of the vas meets the neck of the vesicle serves to prevent such reflux, as does also the simultaneous contraction of the smooth muscle fibers of the ampulla and vas, which are very thick at this point, and which urge the semen obliquely downward through the open ejaculatory duct readily in its path. A clear passageway through the dilated urethra is provided by the act of erection.

Expulsion of semen from the urethra. The expulsion of the semen from the urethra is accomplished by a slow, progressive contraction of the circular fibers that surround the elastic canal, followed by a sudden intermittent and rhythmic one after which the bulbocavernosus muscle contracts, either directly or through the intermediary of the bulb and vesicles. The semen that has arrived in the urethra occupies a cavity lying between the verumontanum behind and Wilson's muscle in front, which constricts the urethra. As the vesicles contract, this muscle is forced open, allowing part of the semen to pass through; then the jet is interrupted by a fresh contraction of the constrictor urethræ. This alternate play of vesicular and urethral muscular contractions is repeated until ejaculation is completed, the rhythm being due to successive relaxations of the urethral sphincter and to what Luys calls " veritable tetanic contractions " that project the semen on its way.

It becomes evident, therefore, that the seminal vesicles, in addition to being reservoirs and glandular organs, play an important part in projecting the semen into and through the urethra, by means of impulses originating in the spinal cord and transmitted through the sympathetic system to the vesicles and vasa deferentia.

CHAPTER VI

SURGICAL PATHOLOGY OF THE SEMINAL VESICLES AND VASA DEFERENTIA

I. SURGICAL AFFECTIONS OF THE SEMINAL VESICLES

VESICULITIS

MORE than half the pathological conditions of the seminal vesicles are produced by the immediate infection of these organs with the gonococcus, followed by other infections that are secondary and implanted upon a gonorrheal basis, among which are, especially, those due to the colon bacillus, several types of streptococcus and staphylococcus, the pneumococcus, and the *Bacillus pseudodiphthericus*, as well as other occasional bacterial agents.

The anatomical formation of the seminal vesicles, and, to a lesser degree, of the ampullæ and vasa deferentia, is such that an infection, once established within them, is almost impossible of eradication by ordinary measures. (See Fig. 13.)

Tendency to chronicity. If the seminal vesicles were simply hollow viscera, like the vagina or uterus, their surgical drainage would be a relatively simple matter; but the extraordinary number of sacculations, convolutions, and diverticula by which they are characterized militate against the elimination of infective agents when once they have taken up their abode here. The chronicity of vesicular infection, and its tendency to spread to the vas deferens and epididymis once it has become implanted upon the vesicle, are thus almost foregone conclusions. The periodic absorption of infective material from the vesicles into the blood and lymph streams is now known to be responsible for certain arthritides or so-called gonorrheal rheumatism, and is also believed to underlie certain functional psychoses or toxic infections of the nervous system, resulting in grave forms of mental disorder.

Other predisposing factors. In addition to the immediate introduction of the gonococcus and other bacterial agents from the anterior and posterior urethra, certain predisposing causes and

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constitutional factors undoubtedly play a rôle in the initiation or reawakening of inflammatory conditions of the spermatic tract. Among these may be mentioned masturbation, sexual excesses, coitus reservatus or interruptus, and alcoholism, which, by promoting continual excessive congestion of the tissues concerned, act as traumatizing agents, the effect of which is to invite the colon bacillus into activity within the tract. The abuse of nicotine, coffee, and tea may have a similar effect. Prolonged bicycle riding or jolting upon a motorcycle, or even horseback riding, has been observed to exert an injurious effect upon the seminal vesicles, as does overexertion from other forms of exercise, such as walking, tennis, and the like.

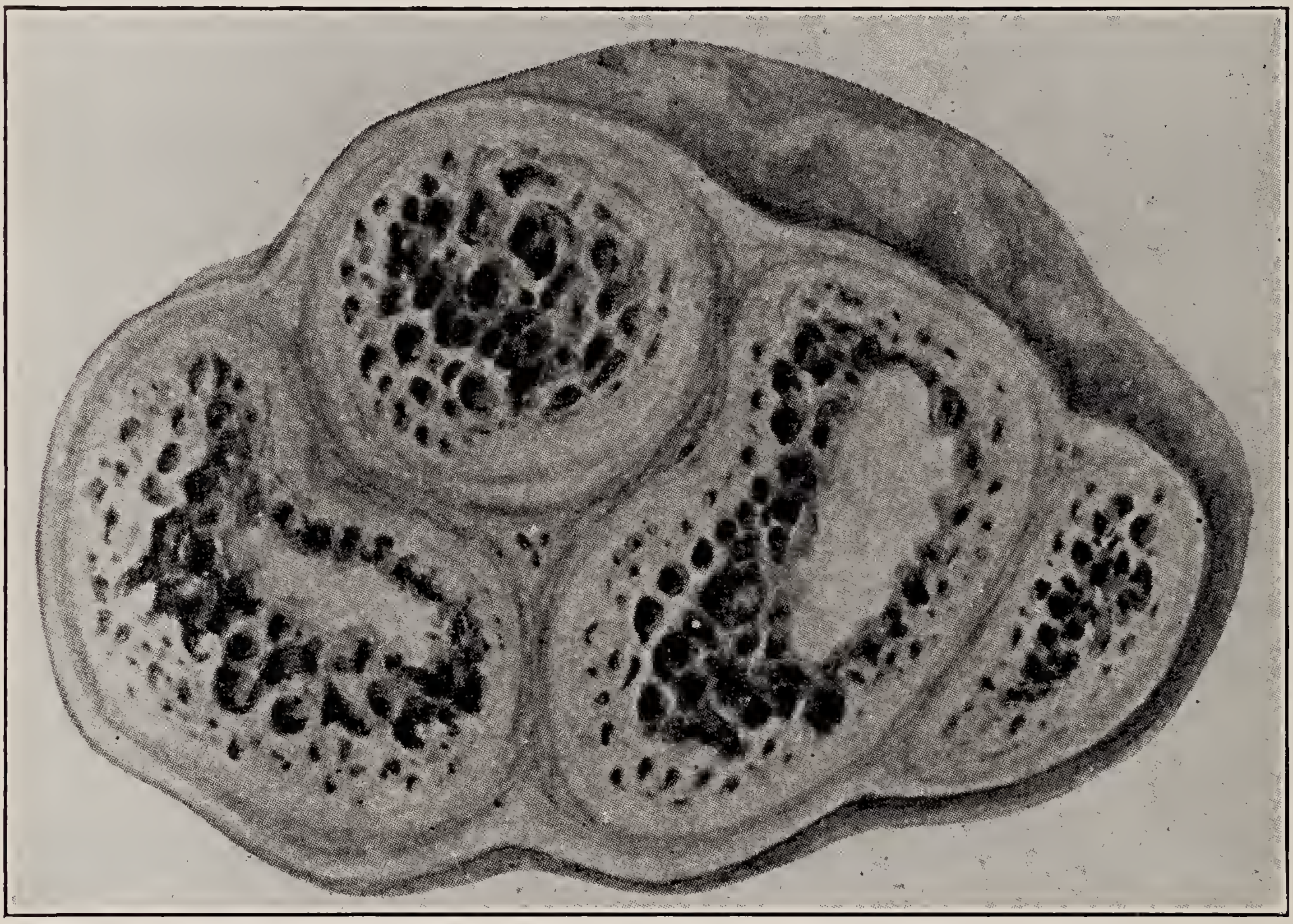


Fig. 13. Cross section of the seminal vesicles, showing the interior network with its extraordinary number of sacculations, convolutions and diverticula, which render surgical drainage by simple vesiculotomy or multiple incisions practically impossible for the elimination of infection, thereby explaining the tendency to chronicity in vesiculitis. (Redrawing from B. A. Thomas.)

Infection is known to be carried from the rectum to the seminal vesicles through the wall of the large intestine, and occasionally through the blood. The main source of infection is, however, through the intermediary of the prostate, an infection of the latter nearly always preceding that of the seminal vesicles and spermatic tract.

Acute vesiculitis. Early descriptions. As long ago as 1840, Faye, a Norwegian army surgeon, wrote a thesis in which he discussed everything then known about the pathology of the seminal vesicles, calling attention to their inflammation, suppuration, induration, scirrhous degeneration and hypertrophy. In 1859 Rapin, in France, gave an excellent description of the symptomatology of acute vesiculitis in a thesis entitled "*Inflammation of the Seminal Vesicles and Ejaculatory Ducts.*" These early writers already recognized that an inflammation starting in the urethral canal followed the course of the ejaculatory ducts and invaded the vesicles. They also knew that at the beginning of an orchitis rectal examination revealed tenderness of the seminal vesicle and the corresponding lobe of the prostate.

Gonorrheal origin of the infection. Today we know that acute vesiculitis is nearly always, if not always, of gonococcal origin. Beginning as an anterior urethritis, the infection spreads within a few days or weeks to the posterior urethra, after which it may take any one of four directions: (1) to the bladder, ureter, and kidney; (2) to the prostate, ejaculatory duct, vesicle, vas, epididymis, and testis; (3) by contiguity, to the peritoneum in contact with the seminal vesicle and vas, and (4) into the blood stream, to produce septicemic or generalized blood infection with its multiple complications.

Pathology of the infected seminal vesicle. When the vesicle is acutely infected, there may be, in addition to internal inflammation of its mucosa, a periurethritis, perivesiculitis, or perideferentitis. The possibility of a complicating peritonitis should always be a source of concern, such cases sometimes going on to a rapid and fatal termination. The vesicle contains a sanguineous fluid (hemospermia) which soon becomes purulent (pyospermia). Abscess formation is frequent, with a tendency to open into the rectum, but in some cases the collection discharges instead into the bladder and peritoneum, with possible ascending infection and perinephritic abscess formation or development of subperitoneal phlegmons. Examination of the interior of the vesicle reveals a striking picture due to the abnormal development of projections of its internal surface, resembling synovial folds, some of which are even visible to the naked eye; these form a sort of lacework around the central cavity. The villosities become swollen and vegetate; the largest ones anastomose to make alveoli. The mucosa becomes double its normal thickness and exhibits a vegetative and suppurative inflammation, with engorged blood vessels, in great part desquamated.

Associated ampullovasitis or deferentitis. In acute inflammations the vas deferens also ordinarily becomes dilated at the level of the ampulla (ampullitis), and its sacculations become covered on the external surface with arterial ramifications. The ampulla is filled with a thick gray substance unlike normal semen, and contains an excess of leukocytes. Spermatozoa tend to be absent, or, if present, they are deformed or have lost their motility. Cystitis is frequently present, by direct extension through the wall of the bladder at the trigone.

Concomitance of prostatitis. Almost without exception the prostate is inflamed before the vesicles and vas, and the mechanism of the vesicular infection appears to be as follows: After the suburethral glands of the prostate have become infected, the pus flowing from their orifices naturally collects about the verumontanum, especially in the small depressions at its sides, from which it readily enters the ejaculatory ducts and passes to the seminal vesicles and ampullæ. The ejaculatory ducts, being very minute, easily become occluded by the thickened mucous discharge, and prevent drainage of the acutely inflamed vesicle and ampulla. Through the latter the infection may spread to the epididymis, but the testicle usually escapes.

Chronic vesiculitis. The direct cause of chronic vesiculitis is usually a chronic urethritis or verumontanitis. Contributory causes may be found in retention of urine from contraction of the urethra or from hypertrophy of the prostate, and in dilatation of the ejaculatory ducts. Frequently one may find in elderly urinary patients that the seminal vesicles, bladder neck, prostate, and rectum have become adherent into a dense connective tissue. In this case, inflammation starting from the bladder or prostate invades the adjoining tissues and enters the vas and seminal vesicle. Meantime, the characteristic formation of the vesicle has fitted it to be the permanent abode of a certain number of latent bacterial tenants, which are readily aroused into fresh activity whenever pus enters from surrounding tissues.

In addition to dilatation of the vesicle, hypertrophy of its walls is frequently present, with enormous increase in the size of the viscus, which may exhibit extensive infiltration in the more extreme cases. The hypertrophy is accompanied by induration. There is varicose dilatation of the surrounding veins, which may also contain phleboliths. Bands and trabeculæ form, and the vas deferens may be obliterated or nearly so. In a late stage the vesicle undergoes atrophy, its cavity becomes effaced, and the organ contracts into a hard fibrous cord.

Involvement of the ejaculatory ducts: stricture. In relatively mild cases of chronic infection of the seminal tract, the juxta-urethral structures are the only ones involved, the ejaculatory ducts being immediately infected from the urethra at the verumontanum. Where the grade of urethral inflammation is low, these ducts may be the only part of the spermatic tract affected, the infection not reaching the seminal vesicles. In cases where the seminal vesicles are severely infected, marked inflammation of these ducts has regularly been observed. Normally, the ejaculatory duct prevents reflux of urine into the vesicle, but if its walls are stiffened by inflammatory infiltration it cannot do this, and, as a result, the reflex passage of infected urine from the bladder to the seminal vesicle may serve to maintain or aggravate a vesicular infection already present. In chronic duct inflammation, complete obstruction is often met with, probably as the result of edema. This may be temporary or permanent. In the latter case drainage through the duct becomes impossible, and this *obstructive condition*, or *stricture*, is followed by loss of contractility in the vesicle itself, from infiltration and gradual fibrosis, with sterility and impotence as its final results.

Lesions of the verumontanum. As a rule, an acute verumontanitis precedes every case of infection of the ducts and seminal vesicles, and may be held responsible for the spread of infection into the spermatic tract. The lesions observed on the verumontanum, as the result of inflammation, exhibit a great variety of forms and characteristics. There may be nothing beyond simple congestion, but it is not infrequent to find erosions, granulations, excrescences, hypertrophy, swelling, distorted contour, polyps, cysts, or papillomata. The original conformation may be transformed almost beyond recognition as the result of chronic irritation and inflammation. Many of these conditions can be corrected by local medical treatment or by fulguration. Ordinary vesiculitis is the common factor in all these cases. The pathological process may pass into the vas deferens, on one or both sides, producing a thickening with more or less complete occlusion from inflammatory detritus, which swarms with various kinds of bacterial life. The presence of these abnormal conditions of the verumontanum results in dysuria and frequency, as well as in various genito-spermatic disorders.

Perivesiculitis. Varying degrees of perivesiculitis and periprostatitis accompany vesiculitis, resulting in changes that run the gamut from small cicatrized areas to large plaques of dense scar tissue. These constrict the vesicles and render them incapable of emptying; they also make them more susceptible to infection. In most cases of vesiculitis the suppurative process passes through the wall of the vesicle and involves the connective tissue immediately surrounding the organ. When such suppuration becomes localized we have a perivesicular abscess, requiring surgical intervention.

Perivesicular thrombophlebitis. Three cases are on record in which the infection passed through the wall of the vesicle and caused a thrombosis of the surrounding venous plexuses.

Peritonitis. Under the pressure of distention, a vesicle may occasionally rupture into the peritoneum, and thus set up a peritonitis. If there is suprapubic and lower abdominal pain, with rigidity, high temperature, leukocytosis, and other cardinal symptoms of an acute abdominal condition, this speaks for a pelvic peritonitis, which may readily be mistaken for acute appendicitis.

Pelvic abscess. Rupture of the vesicle may cause the pelvic cellular tissue to become inundated with pus, thus giving rise to a pelvic abscess. Such an abscess may extend along the sheath of the vas and open at the inguinal ring; or it may produce infection along the entire length of the vas, with periorchitis and finally hydrocele or pyohematocele.

Diverticulitis in the vesicle. Sometimes an infection of the seminal vesicle may be restricted to some one or more of the convoluted diverticula of which the gland is composed, becoming localized there and exhibiting no tendency to become diffused. Such sequestration may, however, be very hard to overcome in view of the difficulty of draining such cavities, where gonococci or other virulent strains of bacteria may colonize and flare up into fresh activity from time to time.

Ischiorectal abscesses. The close relationship of the ischiorectal fossa with the seminal vesicles makes it easily possible for the suppuration within one of the vesicles to burrow around the rectum, penetrate the levator ani muscle, and so extend into this fossa, where the loose areolar tissue of the space breaks down and permits formation of a good-sized abscess. Depending on the direction and extent of the process there may be, similarly, superior or posterior pelviorectal abscesses, or even localized suppuration about the kidney, resulting in perirenal abscess.

Acute pelvic cellulitis. The perivesiculitis and periprostatitis that almost invariably accompany inflammations of the upper spermatic tract may in some cases lead to acute pelvic cellulitis, manifested by suprapubic and abdominal tenderness, perineal pain, and urinary retention.

Pyovesiculosis. When the ejaculatory ducts become occluded by plugs of mucus and pus, or become swollen and edematous, the seminal vesicles respond with empyema or cystic dilatation, which again may cause retention of urine. The engorged condition of the vesicles in a state of acute suppuration leads to a generalized pyovesiculosis, in which the vesicle becomes a closed sac filled with pus.

Urinary-tract reactions to chronic vesiculitis. When vesiculitis is of long standing, definite reactions occur within the urinary tract by reason of its close association with the seminal vesicles, resulting in pathological conditions, with urinary symptoms that may mask the source of the disturbances. Among these may be mentioned the following:

Trigonitis. In certain cases, inflammatory changes of the seminal vesicles extend backward and involve the trigone and neck of the bladder. Passing just beneath the mucosa, the infection attacks the muscles of the trigone, at the same time involving the Albarran subcervical group of glands and giving rise to various disturbances of urination. The stiffened, unyielding vesicles, adherent to the bladder wall, may cause extravasation at the site of adhesion. Cystoscopic examination reveals a definite trigonitis, and sometimes the outline of the bulging vesicle can be made out on the bladder floor. McCarthy and Ritter observed a case in which a large chronic seminal vesiculitis, causing definite pressure on the lower end of the ureter, gave evidence of obstruction to the outflow of urine and resulted in symptoms referable to ureteral colic and formation of hydronephrosis.

Cystitis. Not only does the trigone readily participate in the inflammatory condition of the vesicles lying close behind it, but the entire bladder may set up a chronic cystitis. In the past, many cases of this kind, originating in the vesicles, were erroneously diagnosed as simple chronic cystitis.

Urinary retention. When the congestion and edema of the posterior urethra, due to seminal vesiculitis, are great enough, they may interfere seriously with the emptying of the bladder, causing urinary retention. In the majority of cases of gonorrhea an occurrence of this kind is generally due to conditions in the vesicles rather than in the prostate, though, of course, both may contribute to this result.

Vesicular albuminuria. The globulins and albumoses that constitute the protein part of the secretions of the seminal vesicles become mixed with the urine as they are excreted into the posterior urethra and find their way into the bladder. In chronic vesiculitis a nitric acid test will frequently cause a precipitation of globulins, indicating a vesicular albuminuria, or, more properly, a globulinuria.

Phosphaturia. In patients suffering with chronic vesiculitis the urine is characterized by a diffuse turbidity caused by the presence of phosphates. As a result of the discharge of the alkaline contents of the prostate and seminal vesicles, in a state of chronic inflammation the phosphates normally present in the urine become precipitated. A study of cases of this nature reveals that the kidney is not the only organ responsible for phosphaturia, but that the vesicles may equally be incriminated.

Prostatism. Chronic congestion of the seminal vesicles and vasa in old men often simulates prostatic hypertrophy in cases where, upon examination, no fibrous transformation or contracture of the bladder neck is observed, thus constituting that condition referred to in the literature as "*prostatisme sans prostate.*"

Ureteral and renal colic. The close anatomical relationship of the ureter to the seminal vesicle, and especially to the ampullar portion of the vas deferens, may cause inflammatory conditions of these organs to impinge painfully upon the ureter, the distention of the vas or vesicle sometimes making such pressure upon the ureter as to result in ureteral and even renal colic, accompanied by obstructive anuria or the formation of hydro-ureter and uretero-hydronephrosis. In hypertrophy of the prostate with distention of the bladder, the crossing of the vas deferens produces obstruction in the lower portion of the ureter, interfering with its dynamic and physiological contractions, which causes ureteral and renal colic, as well as urinary stasis.

Spermatic colic. Whenever an ejaculatory duct is blockaded from any cause, whether it be a concretion, calculus, or muscular spasm, the result is spermatic colic, characterized by sudden sharp pain at the close of coitus and by absence of ejaculation. The pain is felt in the deep parts of the spermatic canal, and may extend all the way from the anus to the end of the penis. It is absolutely characteristic, calling attention at once to closure of the ejaculatory ducts. It is interesting to note that if one of these ducts is closed, both are closed, and no semen comes through. This has been explained by some authors as due to a reflex spasm of the second duct, and by others as due to the close proximity of the ducts to one another, so that a stone occluding one will also make pressure upon the other.

Histopathology of the chronically inflamed spermatic tract. Studies carried out by Hyams, Kramer, and McCarthy have shown that chronic inflammatory pathological changes in the seminal vesicles are most frequent in cases where there is frank advanced sclerosis of the posterior urethra and vesical neck, cribriform deformity in the region of the verumontanum, and dilated, sclerosed, patent prostatic ducts. No seminal vesiculitis of any great severity was seen by them without definite marked inflammation of the ejaculatory ducts. In the more marked cases, the vesicles exhibited high-grade perivesicular and vesicular infiltration by polymorphonuclear leukocytes and plasma cells, with striking perivascular cellular exudation about many of the vessels in the perivascular tissues and the muscularis. The duct lumen showed many desquamated epithelial cells mixed with pus and plasma cells. There was a certain amount of submucous cellular infiltration as well. In these cases, fibrotic changes were found in the submucosa of the urethra and vesical neck; the verumontanum exhibited definite acinous distortion and cystic dilatation, with intraglandular and periglandular round-cell infiltration. The duct of the seminal vesicle sometimes revealed numerous engorged blood vessels with a slight amount of perivascular round-cell infiltration. Only in the presence of active, destructive, suppurative adnexal inflammation was marked perivesicular inflammation found. Such cases showed corresponding changes in the wall of the vesicle. In long-standing cases the perivesicular changes vary from small cicatrized areas to large plaques of dense scar tissue, continuous with the capsule of the prostate; they constrict the vesicles, and render them incapable of emptying themselves, as well as less resistant to infection.

Vesiculitis versus appendicitis. In any large general surgical service, where many thousands of appendectomies have been performed for chronic appendicitis, it is a common experience to have patients complain that the pain in the right lower quadrant still persists after appendectomy. In such cases a routine check-up reveals that in many instances lesions of nonappendiceal origin are responsible for the pain. The symptoms of vesiculitis, when these are acute, frequently exhibit a strong similarity to the pains of appendicitis. No appendectomy should ever be carried out in a male patient without a rectal examination first being made. Patients may be seized with an acute attack of abdominal colic which involves the entire abdomen or which may affect chiefly the right iliac fossa; vomiting and tenderness over McBurney's point may exactly simulate an acute attack of appendicitis. The reason is not hard to find: the vesicular and perivesicular infection in its spread involves nerve terminals that cause stimuli to pass to the spinal cord, whence they are transmitted to other visceral regions supplied from the same centers and plexuses. The pain may be severe, sharp, and dragging, or it may shoot upward from the spermatic tract to the crest of the ilium. Many an unnecessary appendectomy could be avoided if it were made a matter of routine to examine the condition of the vesicles and prostate before proceeding to operate for an appendicitis that does not exist.

Kartal reported 5 cases in which this mistaken diagnosis had been made. Many other authors have reported similar cases and have discussed "*appendicitis sine appendice*", as well as the causes of pain in the lower right quadrant. Lowsley and Twinem, in a follow-up study of 84 patients who had been treated for pain in the right lower quadrant, showed that 31 had been subjected to appendectomy and 8 to other major abdominal operations without relief of symptoms. Upon subsequent urological examination all were found to be suffering with some kind of lesion in the urogenital tract. In all cases where vesiculitis is responsible for the pain, rectal examination will leave no doubt of the inflamed condition of the vesicles, which will be revealed not only by their size, consistency, and engorgement, but also by the patient's sensitivity when they are touched. The distribution of the nerve plexuses in the genito-urinary region is such that patients may have pain in any part of the region supplied. Any pain in the abdomen not readily accounted for by other pathology should suggest the wisdom of investigating the state of the seminal vesicles as a possible source of trouble, especially in view of the great frequency of vesicular inflammation. In addition to a urological examination, a careful history should be taken with reference to any urinary symptoms from which the patient may have been suffering. Many cases are on record in which inquiries of this kind would have revealed the true nature of the trouble.

Traumatic vesiculitis. In certain cases of persistent nonspecific urethral discharge, with slight dysuria and other urinary symptoms, the possibility of a traumatic vesiculitis must be considered. Three types should be kept in mind:

(1) Lesions produced by an external agent.

(2) Lesions produced by interrelationships with neighboring pathological organs.

(3) Lesions produced by the bruising from a stone in the ureter.

(1) As instances of the first type, we have gunshot wounds, injuries from perforating instruments, or indirect traumatism such as results from a fall upon a pointed object. Such injuries are very rare, but have occasionally been recorded in the literature.

(2) On the other hand, lesions of the seminal vesicles due to pathological conditions in nearby organs are rather common. Lesions of this kind may be produced by collections of pus in adjoining organs, or by rupture of the appendix, bladder, or other pelvic viscera; or they may be the result of ureteritis, or of diverticula of either the lower ureter or the urinary bladder. In such cases it is to be assumed that the mechanism of emptying the bladder, with its pouch of infected diverticulum, exerts continuous pressure and produces resultant trauma in the seminal vesicles and ampullæ, leading to vesiculitis, ampullitis, and perivesico-ampullitis. Instances of the effect of such interrelationships upon the vesicles may be seen in the cases reported by Rathbun (see Fig. 14) and by Lowsley and Gutierrez, in which the seminal vesicles have been found closely adherent to the diverticular sacs — that of the ureter in the one case, and that of the bladder in the other.

(3) In the rather frequent cases in which a stone is impacted in the intramural portion of the ureter, the traumatism produced by the calculus may be the direct cause of an acute or subacute vesiculitis, which is sometimes manifested clinically by spermatic colic, painful erections, pain irradiating to the head of the glans penis, or pain in the testis of the side corresponding to the stone.

Vesiculitis following prostatectomy. In 1924 Boyd called attention to a case in which, after removal of the prostate, characteristic symptoms of vesiculitis promptly followed. Later Rathbun made a similar observation: 10 patients who had complained of urinary symptoms previous to prostatectomy were relieved of all symptoms except urinary frequency, which was at first regarded as due to a complicating cystitis and treated accordingly, without improvement. Meantime, the fact was brought out that all these patients were suffering with mild priapism after years without erections.

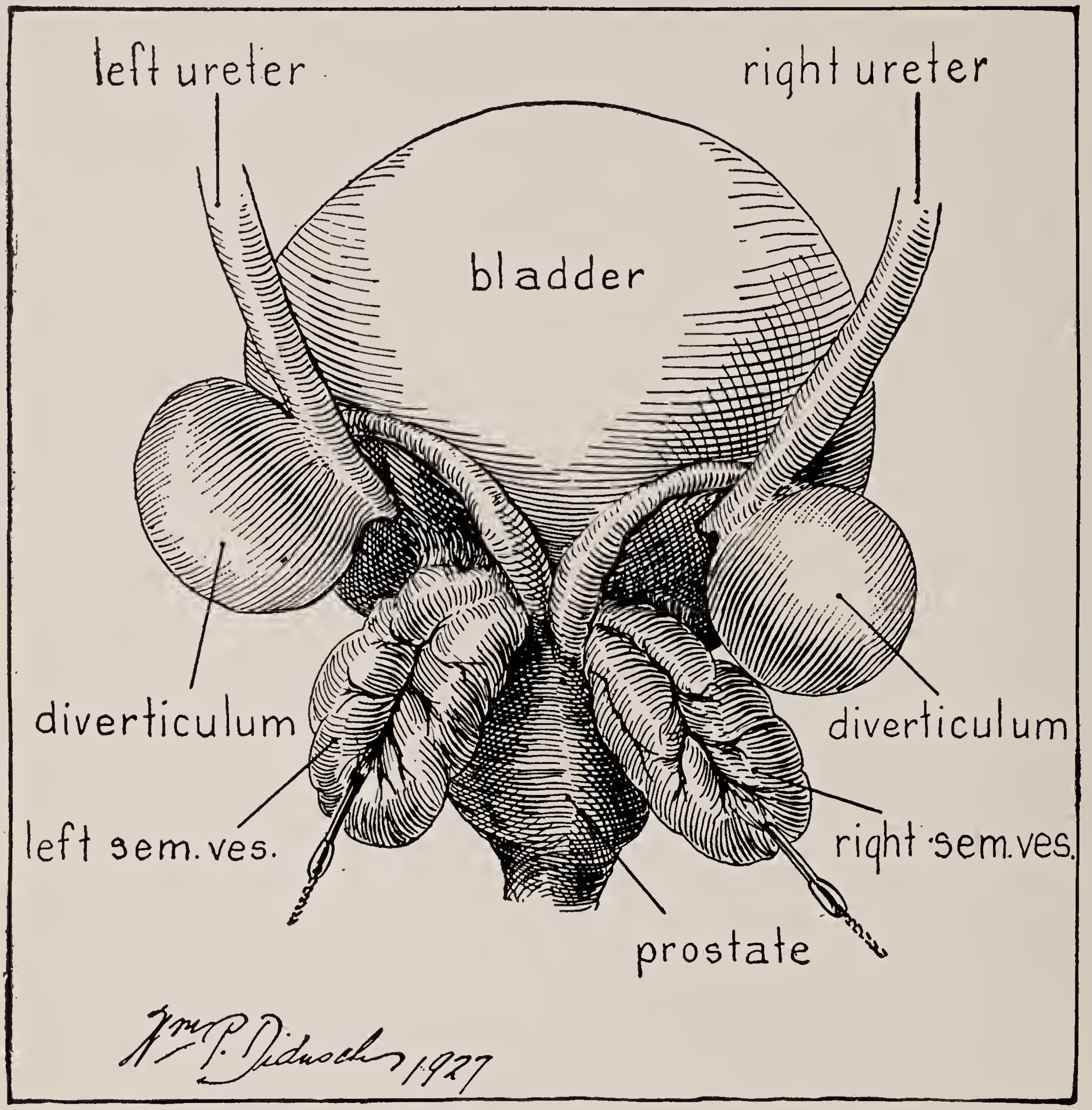


Fig. 14. Drawing illustrating the common factors producing traumatic vesiculitis. Note that in diverticulum of the ureter or bladder, because of the intimacy of these organs with the seminal vesicles, traumatic lesions of the latter are produced. This drawing also shows the close relationship between the ureter and the vesicle which accounts for the "spermatic colic" when a stone is impacted in the intramural portion of the ureter. (Courtesy of Dr. N. B. Rathbun, Journal of Urology, p. 356, [Oct.] 1927.)

Upon rectal examination all were found to present unmistakable evidences of vesiculitis and perivesiculitis. In some the vesicle could be distinctly felt as a thickened, hard, and somewhat tender mass; in others there was a plastic exudate about one or both vesicles extending higher than the finger could reach.

Vesiculitis may reasonably be suspected in any case in which, after prostatectomy, the urinary frequency is out of all proportion to the degree of mechanical obstruction as evidenced by the amount of residual urine. The presence of priapism offers contributory evidence and justifies a thorough examination for vesiculitis. In 7 of Rathbun's 10 cases the condition had not been present until after the operation, thus demonstrating that it was the result of operative interference.

TUBERCULOSIS

The observation that in tuberculosis of the epididymis the globus minor is the point of primary involvement leads to the conclusion that the seminal vesicle is the primary focus of infection in the great majority of cases of genital tuberculosis in the male. According to Young, tuberculosis of the seminal vesicle is responsible for tuberculous infection of the prostate, bladder, and kidney, and is far more dangerous than tuberculosis of the epididymis, being in all probability responsible for the great fatality of genital tuberculosis (27 to 60 per cent.).

Three stages of tuberculosis of the spermatic tract. Three stages exist in tuberculosis of the spermatic tract: (1) an initial stage of "latent microbism," which is the "bacillary catarrh" of Virchow; (2) a stage of caseous infiltration, and (3) a stage of fibrous transformation.

Initial stage. The first of these stages is little known, since the disease has not yet announced itself clinically and on rectal palpation the seminal vesicles appear to be normal. Yet at this very time the tubercle bacillus is starting a proliferative process within the epithelial lining of these organs. Very small miliary granulations begin to appear, microscopically. These little tubercles later unite into pinhead masses which invade the muscularis and dissociate its fibers.

Second stage. The tubercles now become confluent and institute a caseous infiltration. At first the diseased vesicle resembles a mass of frozen convolutions (Verneuil); its outline is irregular, its sacculations are preserved, but the organ is filled with caseous pus, in cavities separated by the usual partitions of the vesicle. These septa soon disappear, the epithelium disintegrates, and there remains an ulcerated surface corresponding to the deep layer of the mucosa or even to the muscularis.

Third stage. A fibrous transformation sets in; all the septa disappear, and the once multilocular organ becomes a single cavity, a mere shell or pyovesicular sac. This may be due to the destruction of the septa, or it may be that one or two cellules increase in size, crowding out all the others; or it may be a combination of the two processes. In any case, embryonal cells begin to infiltrate among the bundles of muscle fibers, and when the fibrous transformation is complete, only the outermost tunic remains to enclose the caseous focus. The vesicle has become a shrivelled fibrous cord with no trace of a cavity. This fibrous coating, however, may form an effective barrier against any further extension of the tuberculous process.

Vesicular fistulæ of tuberculous origin are a rare finding. Occasionally such a fistula perforates into the rectum or bladder (Dufour-Cartaz), or it may open externally. Le Dentu observed a perineal fistula of this type, and cited a case of inguinal abscess in a subject with tuberculosis of the left seminal vesicle.

Self-limitation of vesicular tuberculosis. In a late stage the vesicle becomes completely adherent to the wall of the rectum, but without the tendency to ulceration of the neighboring parts observed in tuberculosis of the prostate, urethra, and epididymis. The fact that the tubercles tend to be limited to the organ itself is favorable for the prognosis. Guelliot observed, however, that when one seminal vesicle has become fibrous the other is always tuberculous. In this late stage the impression that they give to the examining finger in the rectum is that of two infiltrated, distended, and nodular masses, one on each side of the prostate, and sometimes involving that organ.

TUMORS OF THE SEMINAL VESICLES

Historical note. When Guelliot wrote his classic work on the seminal vesicles, in 1883, the only benign tumors of these organs that had been placed on record were a few angiomas and lipomas. Of primary malignant tumors of these organs Guelliot recorded only one case, which was a carcinoma upon which Labbé had operated. The only case of primary carcinoma reported earlier was that of P. Berger (1871), which has never been widely publicized and is of doubtful authenticity as being primary in the seminal vesicle. Guelliot collected 13 cases of secondary carcinoma of the vesicles. In these the primary growth was 8 times in the prostate, 3 times in the bladder, once in a testis, and once in the rectum. No mention is made in Guelliot's work of sarcoma of the seminal vesicles.

It is interesting to compare these early figures with the total number of cases of tumorous growths of the seminal vesicles that have since been placed on record. While the number of primary tumors of these organs still remains small, the cases of secondary carcinoma of the vesicles discovered in the course of operations upon malignant prostate glands has been so large that the question arises whether the vesicles have not been invaded in every case of carcinoma of the prostate.

Primary benign tumors of the seminal vesicles. In addition to angiomas and lipomas, which are occasionally found in the vesicles, there are a few records of myoma, fibromyoma, and cystadenoma. Luksch, in 1903, found a roundish tumor consisting solely of myomatous tissue buried in the fat of the retrovesical space, above the prostate and closely united to the vasa deferentia and seminal vesicles. He believed this tumor to have developed from rests of the müllerian ducts. Voelcker, in 1912, observed a thick-walled painless tumor of similar structure and similarly located, which contained at its center a hollow cavity with a capacity of 100 cc. It was covered with a capsule several millimeters in thickness, composed of connective tissue. Microscopically the tumor was a myoma. Ceelen, in the same year, reported the finding in a man of 67 of a tumor involving the posterior two-thirds of the right seminal vesicle, in which the histological diagnosis was fibromyoma with marked regressive changes, angiomatous at some points. Oehlker, in 1928, published a report of a cystadenoma of the left seminal vesicle that occupied the entire abdomen.

Malignant tumors of the seminal vesicles. Sarcoma, lymphosarcoma, and carcinoma have all been described in the seminal vesicles. Whether such neoplasms are primary or secondary is sometimes difficult to determine. There is a growing tendency to believe that every carcinoma of the seminal vesicles is secondary to a neoplastic growth in the prostate, bladder, rectum, or testis. Nevertheless, it appears that in a small number of cases carcinoma

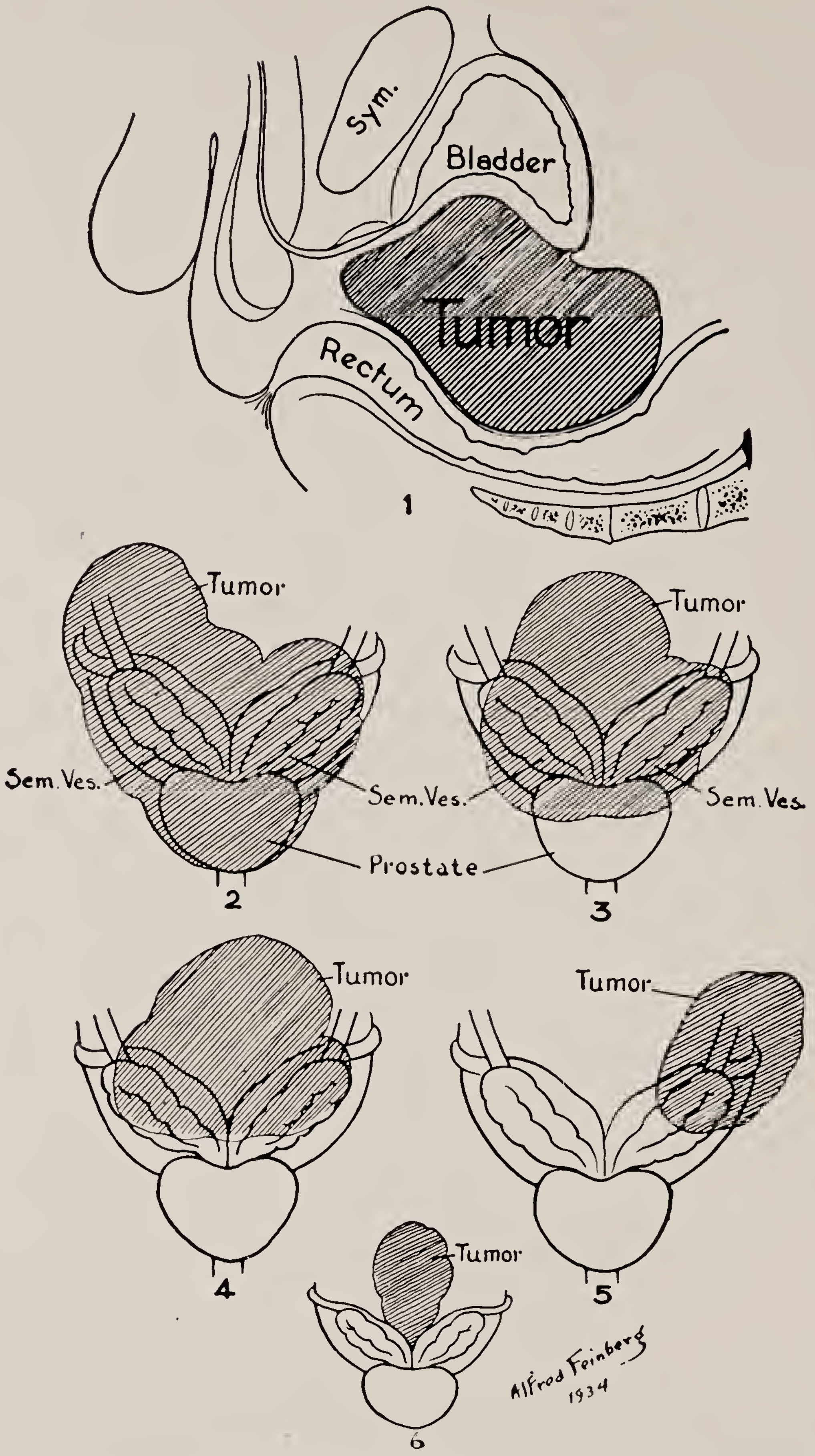


FIG. 15. This schematic drawing illustrates the different forms of malignant tumors arising from the retrovesical space as reported in the literature, particularly the two most common types, sarcoma and carcinoma, as they are found clinically, involving both the seminal vesicles and the prostate.

1. Sagittal view representing the retrovesical tumor, as observed in younger individuals, involving all the organs in the retrovesical space between the bladder and the rectum and sometimes invading these viscera as well.

2. Showing the malignant tumor involving the prostate, both seminal vesicles and ampullæ, and occupying the entire retrovesical space.

3. The tumor arising from the retrovesical space involves half of the prostate and both seminal vesicles and ampullæ, as in the sarcoma type.

4. A lymphosarcoma arising from the retrovesical space has invaded both seminal vesicles.

5. Primary sarcoma or carcinoma originating in a seminal vesicle, and still confined to the single organ, where it is amenable to operation.

6. Drawing of a lymphosarcoma arising from the intervesicular space, without definite involvement of the vesicles or prostate, and easily mistaken clinically for a cyst.

In forms 1 and 2, where the malignant growth has definitely involved the bladder, combined cysto-prostato-vesiculectomy may be indicated, followed by deep x-ray and radiotherapy. In forms 3 and 4, after radiation, surgical intervention may have its place. In forms 5 and 6, perineal excision is the treatment of choice.

has been proved to be primary in one or both of the vesicles, with the prostate and bladder unaffected. There is reason to believe that sarcoma of the seminal vesicles originates in the retrovesical region more often than in the prostate. These forms of malignant tumor will be considered separately.

Primary sarcoma of the region of the seminal vesicles. Clinically, two types of sarcoma must be considered: (1) sarcoma arising from the tissues behind the bladder in the retrovesical space, in which there is definite involvement of the seminal vesicles, and (2) new growth developing in the prostate and extending intravesically, sometimes involving the whole bladder, as seen especially in children, where it finally extends to all the pelvic organs. Sarcoma of the prostate or seminal vesicles, as described in the literature, is, in Young's opinion, in most cases really *sarcoma of the region of the seminal vesicles.* He holds that the disease is first retrovesical and involves the prostate only later.

Bumpus has found 70 cases of sarcoma of the prostate in the literature, and reports *in extenso* 5 cases from the Mayo Clinic. By Young's criterion, all these would be, in reality, malignant tumors of the retrovesical region, involving the seminal vesicles at the same time as the prostate. (See Fig. 15.) According to Bumpus, rapidly growing lymphosarcoma, composed almost wholly of the single type of cell, and containing little or no connective-tissue stroma, will usually be found as a soft, boggy tumor of considerable size, sometimes difficult to distinguish from prostatic abscess. In one case, however, in a man of 64, he found a lymphosarcoma that was uniformly enlarged, hard, dense, and adherent. It appears, therefore, that while in childhood or early

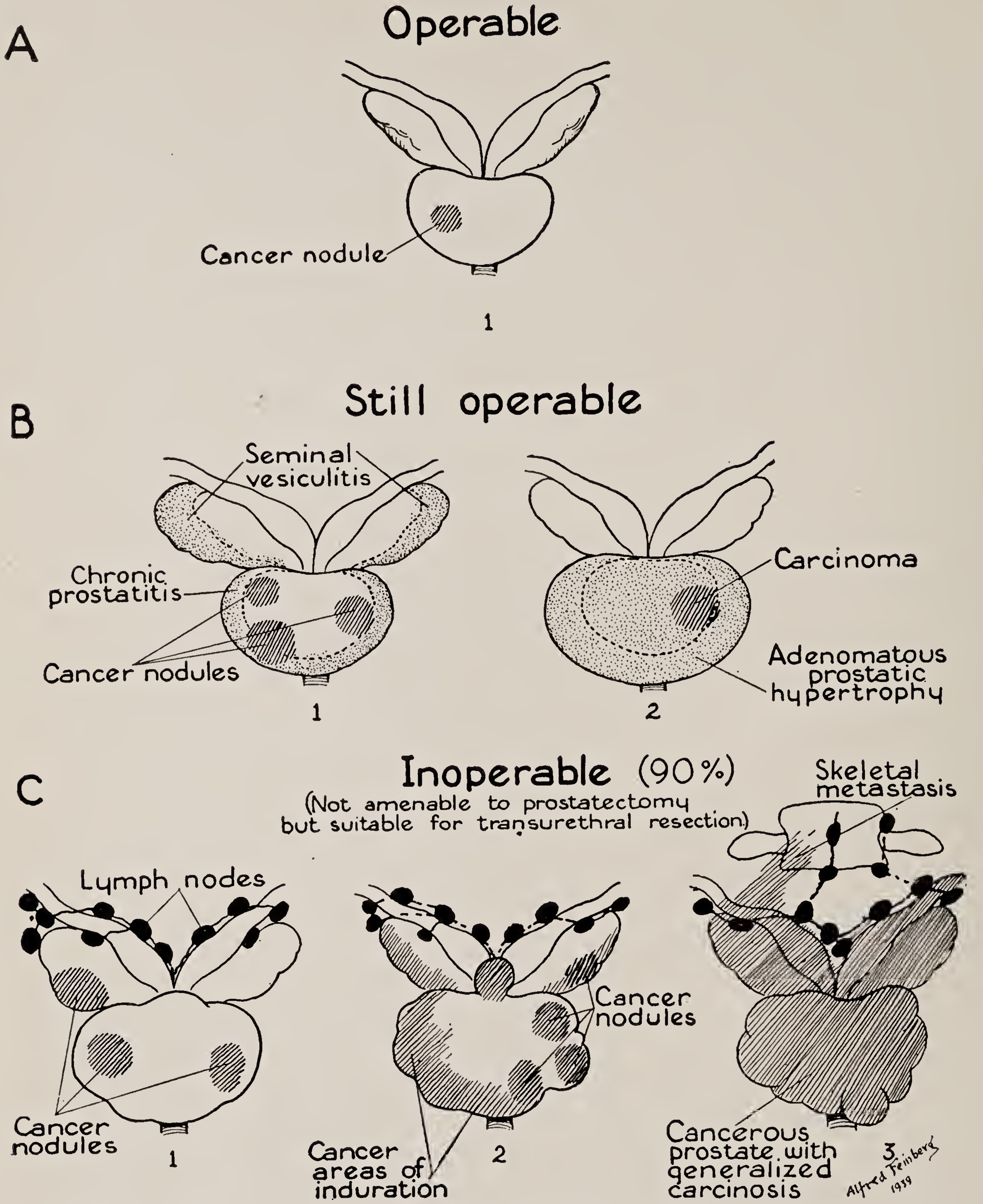


FIG. 16. Schematic drawing showing the different stages by which carcinoma extends into the seminal vesicles.

A. The primary lesion in the prostate has not yet involved the seminal vesicles.

B. The carcinoma of the prostate is associated with chronic vesiculitis and adenomatous prostatic hypertrophy.

C. The carcinomatous disease of the prostate has invaded the seminal vesicles through the lymphatics and has even caused bony metastases.

By the time this secondary carcinoma of the seminal vesicles is discovered it has usually reached the stage shown in C–1–2–3, and is inoperable. In some cases, however, (C–1 or C–2) it appears that the seminal vesicles should be removed with the prostate by a radical perineal prostato-seminal vesiculectomy in order to prevent further extension of metastases. (From Gutierrez: American Journal of Surgery, **68:** 330, 1940.)

adult life such tumors are of soft consistency, the same histological type becomes hard and firm in aging individuals. Bumpus believes that any malignant tumor found in the prostate region before the age of 40 may safely be regarded as sarcoma.

Primary carcinoma of the seminal vesicles. The number of tumors that have been accepted as authentic primary carcinomas of the seminal vesicles varies with different reviewers, some accepting as few as 4, while others recognize 12 or even 16. Schwarzwald, after sifting the literature of the subject in 1928, concluded that the following cases were primary carcinomas of the vesicles: those of Lyons (1925), Kaufmann (1922), Teubert (1903), Brack, 2 cases (1921), Kudlich (1926), and 2 cases of his own (1928). As cases of authentic carcinoma of the vesicles, or of a vesicle, but possibly secondary, he accepts those of Courvoisier-Walter (1891), Labbé (1883) (lacking only microscopic confirmation), Burkard (1904), Fenwick (1887), Rochet (1923) and Thévenot (1926), while that of Berger (1871) is held to be undoubtedly secondary.

More recently, 3 other primary cases have been reported: those of Pelagatti (1934), McNally and Cochems (1936), and Junker (1941). McNally and Cochems have mentioned also the 2 cases of Junghanns, of Dresden, which they found in the archives of the Institute of Pathologic Anatomy (1893 and 1927), and the case of Trachsler (1934), which was probably secondary. There are thus 21 cases which have been reported in the literature as apparently primary carcinoma of the seminal vesicles, accepted by their authors as such. The age of the majority of these patients was between 72 and 87. Quite exceptionally, the case of Junker was in a man of only 30 years, whose symptoms dated from 3 years previously. At autopsy, benign prostatic hypertrophy was found, with carcinoma of the left seminal vesicle, and metastases to lungs, pleura, and liver.

The only authentic case of primary carcinoma of the seminal vesicles diagnosed *in vivo* was that of Oliver Lyons. This diagnosis was later confirmed at autopsy.

Secondary carcinoma. Cancer of the prostate is overwhelmingly the primary focus of vesicular neoplasms, the seminal vesicles being affected in four-fifths of malignant tumors of the prostate gland, either by direct infiltration or by invasion of perivesicular tissue. Bumpus, in a review of 1,000 cases of carcinoma of the prostate seen at the Mayo Clinic, concluded that the vesicles are involved as the result of invasion from a primary lesion in the prostate. Albarran recommended that whenever a malignant tumor of the prostate is found at operation, the seminal vesicles should also be removed with the prostate, as a routine measure, because of the practical certainty that they participate in the malignant process. If they are left behind there is always danger of recurrence of the cancerous condition and of involvement of neighboring structures in the neoplastic disease.

Mode of carcinomatous invasion of the seminal vesicles. Gutierrez has recently pointed out that clinically there are 3 stages of cancer of the prostate. In studying secondary carcinoma of the seminal vesicles, from the point of view of operability, 3 types of cases may accordingly be considered. These 3 types, or stages, are graphically represented in Figure 16.

Passing from the bed of the prostate the malignant process infiltrates in an upward direction along the seminal vesicle on one or both sides. Sometimes two lateral prolongations are felt at the top of the prostate which later meet and form a plastron behind the bladder.

When the vesicle is invaded, the growth takes the form of nodules and infiltrations of the wall; the cavities of the organ fill up with sanious detritus, until it is finally a hard, solid mass, so confusedly adherent to the surrounding tissues that one organ cannot be distinguished from another, the vesicles being continuous with the vas, prostate, rectum, and bladder, as well as with the perivascular tissues. As the cancer grows, the space lying between the vesicle and ampulla of the one side and the corresponding organs of the other side becomes gradually invaded, forming, to the touch, a mass resembling a capsule, which doubles the fundus of the bladder. As a rule the neoplastic invasion from the prostatovesicular region spreads to the neighboring structures, involving the organs of the lower pelvis with metastasis to the bony system, and constituting thereby the generalized carcinosis, or Guyon's *carcinose prostato-vésico-pelvienne*, which is characteristic of the diffused type of cancer.

Invasion of the lymphatics is a nearly constant feature, metastatic nodules forming along the iliac trunks and network and invading the inguinal and lumbar lymph-nodes. Albarran has observed such invasion extending the whole length of the vertebral column as far as the mediastinum, even causing degeneration of the subclavicular ganglions. Throughout the early part of this invasion the clinical course may be that of an ordinary inflammatory process, or the seminal vesicles may even be apparently perfectly healthy yet harbor a carcinomatous process unknown to the patient. According to Marion, the left vesicle is oftener the one first to be invaded. The invasion remains perivesicular for a long time, taking a course around the seminal vesicles and vasa deferentia, which at first remain intact. Even when it has gained an entrance into the spermatic tract, the neoplasm for a long time is confined to the exterior planes and advances but slowly into the cavity, the mucosa long retaining its integrity, contrary to what occurs in tuberculosis. To the examining finger the hard, woodlike mass on the back of the bladder feels like a bull's head and horns.

In 90 per cent. of cases of cancer of the prostate, the patient does not visit the urologist until a late stage has been reached, when the malignant growth has already invaded the seminal vesicles, and the case is beyond all possibility of cure even by radical surgery.

Surgical treatment of tumors of the seminal vesicles. It is imperative that the diagnosis be made as early as possible, by needle aspiration or open surgical biopsy. When the diagnosis is definitely established, each case should be treated according to the individual requirements, which will depend upon the stage the tumor has reached; in other words, whether it is still confined within the limits of the vesicle, or has already metastasized to other near-by organs, to the chest, or to the bony system.

Sarcomatous tumors of the region of the seminal vesicles, which are as a rule the type met with in younger individuals, may be amenable to radical surgery, as illustrated in Figure 15. When the condition has already become inoperable, radium and deep x-ray therapy may be useful to relieve the pain and to control further metastasis.

There are certain cases of early carcinoma of one alone of the seminal vesicles in which it appears that a perineal seminal vesiculectomy is the procedure of choice in an effort to cure the malignant lesion localized in this one organ.

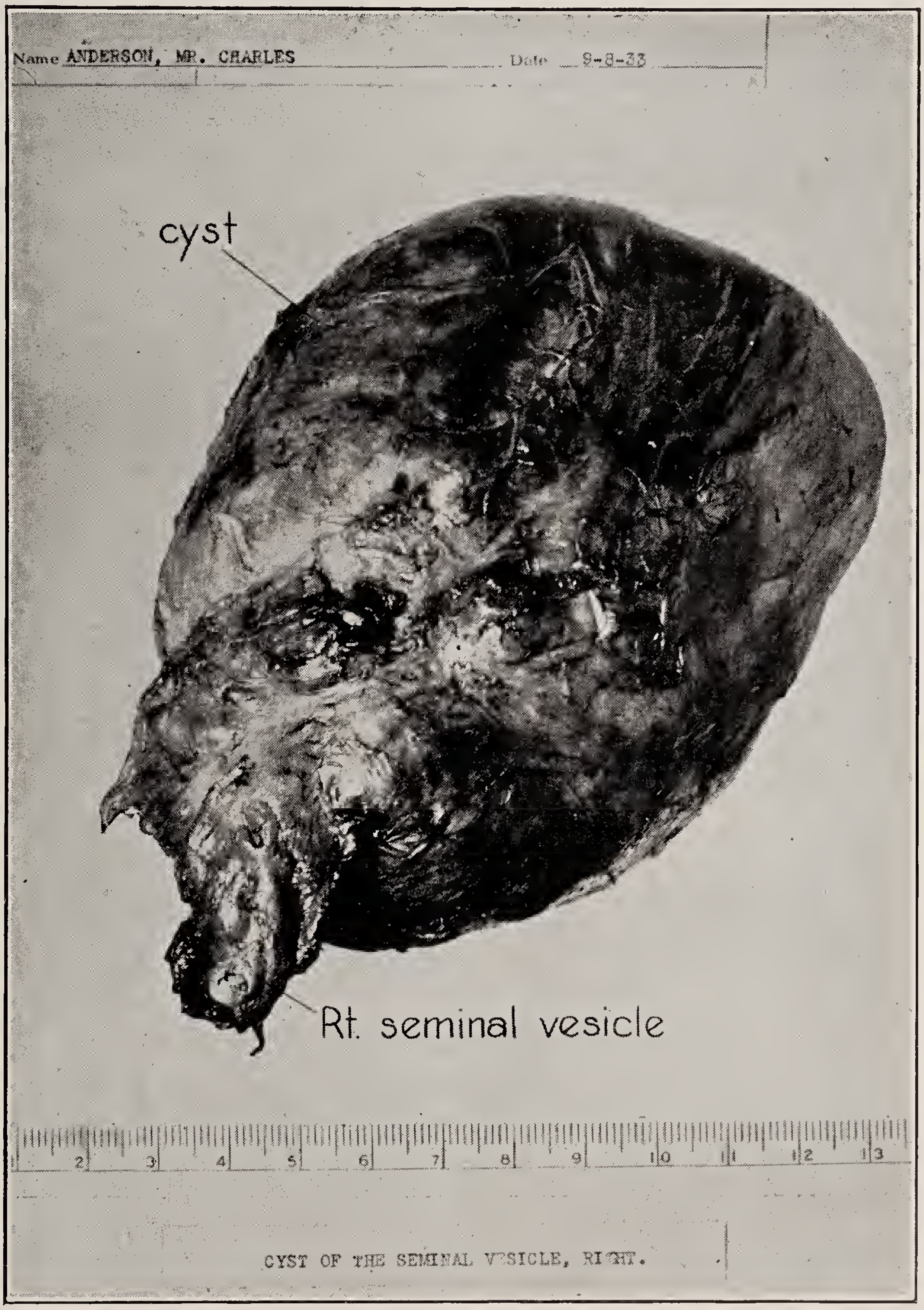
In secondary carcinoma of the seminal vesicles, which is observed in older men and originates secondarily from invasion by a primary lesion in the prostate, the present-day treatment offers two alternatives: (1) If the diagnosis has been made early and the malignant condition is still circumscribed to the prostate and seminal vesicles, with no evidence of metastasis in the roentgenogram, a radical procedure for its total removal by a perineal prostato-seminal vesiculectomy may afford a permanent cure, as is shown graphically in Figure 16 C, 1 and 2. (2) If, however, the carcinoma has invaded the surrounding structures by way of the lymphatics, and has already metastasized to other organs or to the bony system, it appears that the best course is castration.

The use of castration as a mode of treatment of cancer of the upper spermatic tract is still in the experimental stage, but according to recent reports from various clinics and from the literature it seems to give great promise, particularly in the relief of pain and control of metastasis. Huggins and his coworkers made a report on this subject at the meeting of the American Urological Association held in Colorado Springs in May, 1941, in which they stated that remarkable results had been obtained by castration in a series of 50 cases of carcinoma of the prostate with secondary involvement of the seminal vesicles, some of them with multiple metastases, and all of them regarded as hopeless and incurable by any other method hitherto used. It was remarkable to observe the enormous relief afforded these patients after the accomplishment of a bilateral orchidectomy. Clinically it is beyond a doubt that this simple procedure, carried out in accordance with the most modern conception of the hormonal relationships within the male organism, has brought about improvement in these suffering and moribund cancer patients. The method appears, in the light of our admittedly imperfect knowledge, to have its indication in a group of well-selected advanced cases of this type, and is well worthy of trial in situations that have been regarded as hopeless.

CYSTIC AND ECTATIC FORMATIONS

Cystic and ectatic formations between the rectum and bladder are a more or less frequent finding, and are of multiple origin, arising in part from the seminal vesicles and in part from the prostatic utricle and the débris of the wolffian and müllerian ducts. In some cases they attain a great size, and may even fill the entire abdomen in extreme cases, as in hydatid disease.

Ectasia. Obliteration of an ejaculatory duct may produce an ectasia, but does not do so unaided. In order for total ectasia to occur, there must first have been an inflammation of the vesicle



Name ANDERSON, MR. CHARLES Date 9-8-33

CYST OF THE SEMINAL VESICLE, RIGHT.

FIG. 17. Photograph of an enormous cyst of the right seminal vesicle containing 1100 cc. of dark chocolate-colored fluid, which microscopically showed red blood cells and a number of spermatozoa. Specimen removed at operation in a patient 59 years of age. (Courtesy of Dr. C. L. Deming, New Haven, 1934.)

which modified its walls and dilated them, after which the closing of the ejaculatory duct completed the tendency to dilatation. That such inflammatory distentions have been observed is undeniable. They may exist in every intermediate degree, from the most acute empyema of the seminal vesicle to the most chronic hydrovesiculitis (hydrospermatocystitis).

Cysts. Less frequently observed, but still undeniable, are cysts having their point of departure in a seminal vesicle. (See Fig. 17.) These sometimes attain so great a size that the functions of the bladder and rectum are disturbed by their encroachment. A number of authors have called attention to small tumors in the vicinity of the seminal vesicles which resembled hydatid cysts and appeared to be attached to these organs. Bordeu, Lallemand, Pinault, and Sanchez-Coviza have all published such reports. Bosscha saw a case which appeared to be a cyst of the vas deferens, lying between the vas and the ureter on the right side, above the seminal vesicle, attached to the vas by fibrous tissue and a few vessels. It contained a viscid fluid, and its internal surface was reticulated. In some cases the pressure of an adenoma of the prostate upon the ejaculatory ducts has resulted in such cysts. Again, certain diverticula of the seminal vesicle may become strangulated as the result of inflammation. These may be single or multilocular, and may be mistaken for paravesicular cysts. Barnett, after dissecting 100 specimens of pathological vesicles, drew attention to the innumerable blind pouches composing the interior of these organs, and to the possibility of retention cysts following inflammatory changes, as the result of lack of drainage due to duct obliteration.

CONCRETIONS AND CALCULI

Two types of formation have been described under the name *calculi of the seminal vesicles;* these are, in reality, distinct from one another. On the one hand, there are more or less friable masses composed entirely of organic matter, or with a negligible amount of mineral matter, their content being either exclusively mucus or abnormal collections of those small nitrogenous bodies known as sympexions, to which reference has already been made in Chapter V. These organic masses are properly classed as concretions, while the name calculus should be reserved for true stones, composed of calcareous or other mineral substances. In this group we may also consider the complete caseation or calcification of both the prostate and seminal vesicles.

Concretions. When collections of sympexions become sufficiently numerous or large to clog the spermatic secretion, such concretions become pathological. Agglomerations of this kind may be seen in the form of polyhedral masses with blunt angles, measuring 1, 2, or 3 mm. in diameter. They are much more common than the true calculi, and are capable of producing obstructions that result in spermatic colic. The proof that this type of concretion is composed of sympexions and not of mucus is found in the fact that they are soluble in acetic acid. Mucous concretions, on the other hand, will not dissolve thus, but in acetic acid simply take on a striped appearance. The latter generally contain, in addition to mucin, a few sympexions, granulations composed of pigment, traces of calcareous salts, and agglomerations of spermatozoa which may amount to more than one-half of the total mass of the concretion. Gradual transitions appear to occur from these structures containing but little inorganic matter to the true calculi, in which animal substances are nearly absent. Other types of concretions and complete caseation with calcification may be due to an occluded genital tuberculosis.

Calcification of the seminal vesicles occurs slowly and insidiously, and may have reached a high degree before it gives symptoms. Chiari made a distinction between calcification due to chronic inflammatory processes and that occurring as the result of senile changes. The first case ever recorded was that of Hartman, in 1765. The process may extend to the prostate and vasa deferentia. Nemours-Auguste (1936) described a case so far advanced that it had gone on to a beginning ossification, in a man 71 years of age, who suffered with general arteriosclerosis and a localized arteriosclerotic process in one hip. There was calcification of all the arteries in the vicinity and complete calcification of the seminal vesicles. It was stated, in this case, that up to the end there were no urinary disturbances. At autopsy the condition previously revealed in the roentgenogram was confirmed.

Calculi of the seminal vesicles are not a rare finding in elderly men. Their chief ingredient is calcium phosphate, which generally represents about 86 per cent. of the stone, with 2 per cent. of calcium carbonate and 12 per cent. animal matter (Peschier's analysis). This is approximately the same as that of prostatic calculi. The size of the stones varies from that of a pin-head to that of a cherry-stone. The larger ones are, however, an unusual finding. Mitchell observed over 200 calculi of minute size within a single vesicle. Heckel described a case in which the calculi, as seen in the plain roentgenogram, resembled a beaded necklace stretched from one ampulla into the seminal vesicle, and out again into the other ampulla, thus constituting ampullo-vesicular calculi.

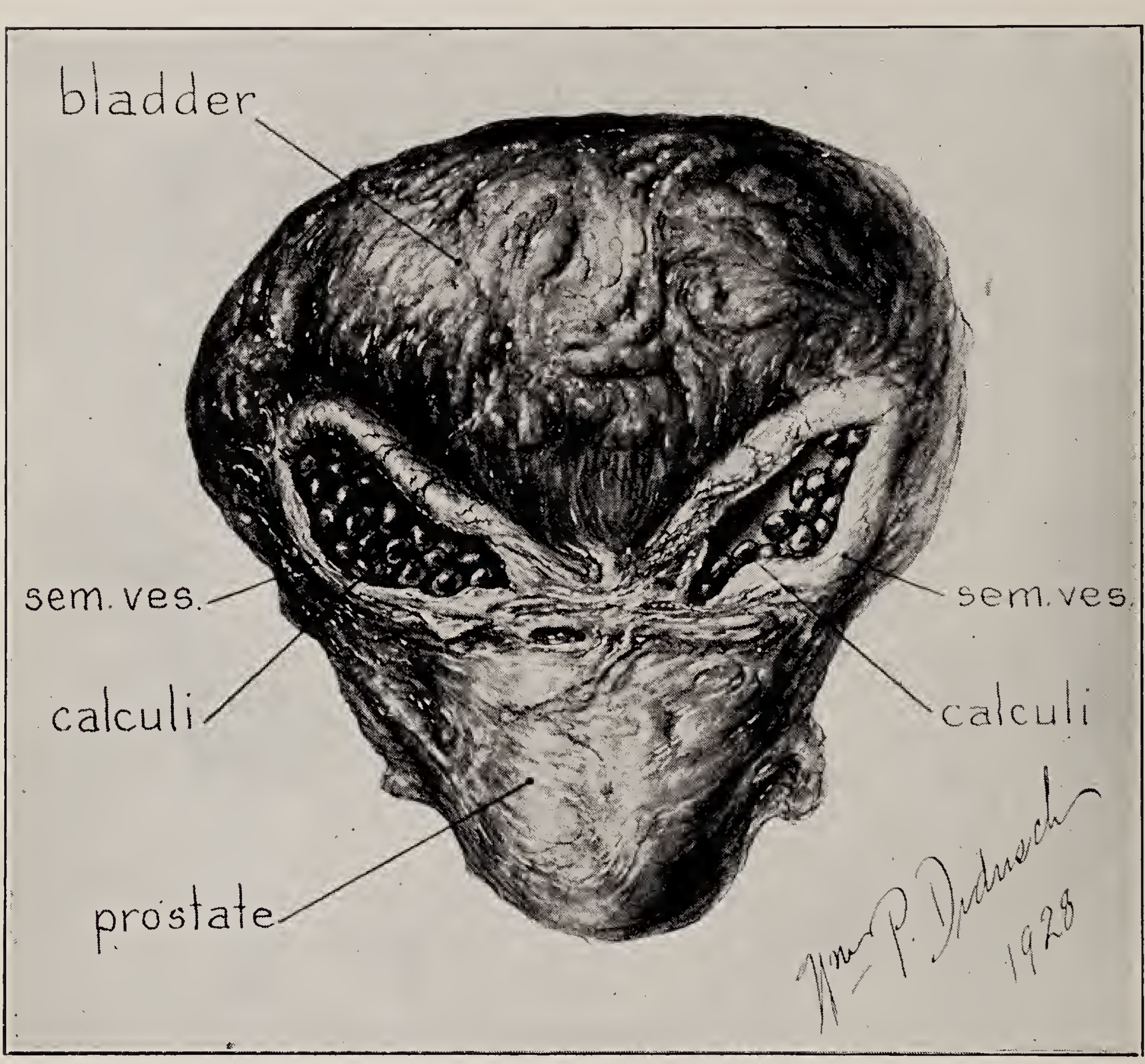


Fig. 18. Multiple calculi in both seminal vesicles. Drawing from post mortem specimen, from a patient 30 years of age. (From Museum of Dr. Christeller, Virchow Krankenhaus, Berlin.)

The cause of calculi within the vesicles has been attributed by some to long inactivity of these organs, with retention of semen. In cases where there is a general arthritic diathesis, however, the cause is likely to be constitutional. Since, however, it is now recognized that the seminal vesicles, when chronically infected, often serve as foci of generalized arthritis, it is easy to understand how such arthritis might first manifest itself in a calcareous condition of the vesicles themselves, producing mechanical obstruction.

The calculi may be unilateral or bilateral, the latter condition being the more frequent. They may be secondary to tuberculous lesions of the vesicles. While many cases have been reported in which no symptoms were present, it is not infrequent to find urinary disturbances and weak and painful ejaculations, sometimes accompanied by hemospermia.

SYPHILIS

Many cases have been reported of syphilis of the seminal vesicles, characterized by induration in some cases, by simple elastic resistance in others. Pathologically there is nearly always a gummatous transformation of the vesicle. The vessels of the serosa exhibit a perivascular infiltration of the plasmatic cells and of lymphocytes, suggestive of the action of the treponema. The evolution of these lesions appears to be very slow, the infection remaining latent for a long period and in early stages producing no symptoms to attract the attention of the patient. In later stages, when other organs also may be involved and the Wassermann test is positive, the condition is obvious. As a rule, these localized syphilitic lesions respond to intense specific treatment.

TRICHOMONAS PROSTATOVESICULITIS

Up to 1927, 4 cases of trichomonas urethritis in the male had been reported in the literature as an accidental finding. In that year Capek made routine studies which resulted in the finding of 2 more cases. Riba, after discovering the trichomonads in the prostatovesicular secretions of two individuals suffering with prostatovesiculitis, undertook a systematic examination of prostatovesicular fluid in the natural state in all cases entering his service during the three-year period 1928–1931. An examination of 3,000 specimens revealed the trichomonas in 9, or 0.03 per cent. Riba thinks this number is too low, since the students examining the smears frequently reported " many motile spermatozoa " which may easily have been the flagellates themselves. The reports show that the protozoa were more numerous in the posterior urethra and that hematuria, either microscopic or abundant, was a cardinal symptom. The symptoms were itching and a burning sensation in the urethra, with a discharge which contained motile active trichomonads, a few motile spermatozoa, many pus cells with clumps (25 to 30 per h.p.f.), and a greater or less number of red blood cells. Bleeding was severe after catheterization. In Riba's cases the symptoms cleared up promptly after instillations of acriflavine and silver nitrate. Riba thinks it probable that many cases go undiscovered simply because they are not looked for. To discover the flagellates it is necessary to examine the prostatovesicular fluid in the natural state without stain; ordinary stained smears will not reveal them.

II. AFFECTIONS OF THE VASA DEFERENTIA

Infections of the vas deferens, as the result of infection anywhere in the spermatic tract — seminal vesicle, urethra, prostate, epididymis or testis — fall naturally into two groups: *acute* and *chronic.* These are again divided into two sub-groups: *specific* and *nonspecific.* From a surgical and anatomopathological point of view, however, especially as regards treatment, they may all be discussed together under the headings which follow.

VASITIS

In infections of the seminal vesicle the vas deferens may or may not be involved. When it does participate in an infection, the ordinary acute changes are observed concomitantly with the acute symptoms in the vesicle itself. These may supposedly be due to the creeping of the infection along the mucosa or the lymphatics of the vas. When a vasitis becomes chronic, fibrosis sets in; the walls thicken and may become nodular and painful; the vas becomes contracted and stenosed and in extreme cases this condition may go on to complete occlusion.

An infection of the vas coming from the seminal vesicle is readily passed on to the epididymis by way of the globus minor, where it becomes the source of untold mischief, leading to acute and painful epididymitis and sometimes to orchitis. On the other hand, infection from the epididymis to the vas is also a common occurrence, and such infection may pass upward through the lumen of the vas and involve the ampulla and seminal vesicle of the corresponding side. The intermediate portion of the vas within the cord presents various degrees of thickening, induration, and tenderness after a chronic inflammation has become established. In acute conditions of the testis and epididymis the vas may be involved to such an extent that funiculitis, vasitis, and ampullitis result. Also, in traumatic lesions of the scrotal contents it is common for the vas to share in the resulting inflammatory condition.

Perivasitis may complicate all urethral suppurations. It is seen especially in gonorrheal vasitis where the latter follows an acute course.

AMPULLITIS

It is obvious that ampullitis *per se* is difficult to isolate, in view of the close anatomical relation of the ampulla to the seminal vesicle and the fact that these two organs unite in a common duct to form the ejaculatory duct. It may be assumed, however, that where there is verumontanitis, or, more properly speaking, obstruction of the ejaculatory duct, or stone formation, the inflammation of the duct will produce a stagnation and possible infection in the ampulla as well as in the vesicle. Nevertheless, there is evidence that ampullitis *per se* may occasionally develop by direct or indirect infection through the lymphatics or the blood stream, or by contiguity. It has also been observed that after vesiculectomy, when the ampulla has not been torn off from its proper connection during the anatomical dissection, it will itself become the active reservoir of the semen, as Gutierrez has pointed out in his report of 100 consecutive vesiculectomies. Several of these cases revealed, when reexamined five to six years after operation, that the ampulla had not only replaced the seminal vesicle functionally, but had itself become infected and was suffering definitely with ampullitis, as revealed by its enormously distended wall and grapelike sacculations.

Ampullovasitis. When both the ampulla and the adjacent portion of the vas deferens above it become infected, we have the condition known as ampullovasitis, with inflammation and sometimes suppuration of both these structures, which may in severe cases extend downward along the sheath of the vas and produce an epididymitis.

TUBERCULOSIS OF THE VAS DEFERENS

In tuberculous vasitis it is possible to palpate the vas in the inguinal canal or even above it on deep abdominal pressure. The tuberculous vas is distinguished from other types of inflammation by the beaded character of the induration and also by the striking enlargement it undergoes. It is commonly nodular and filled with tuberculous caseous masses and calcifications of tuberculous origin. When the inflammation spreads from the infected vas to the elements of the spermatic cord, the latter responds with pain and swelling along its course. Tuberculosis of the vas, like tuberculosis of the ureter, means tuberculosis of one of the organs at its extremities: in the urinary tract, the kidney or the bladder; in the spermatic tract, the seminal vesicle or the epididymis, and sometimes the prostate itself.

TUMORS OF THE VAS DEFERENS

Lipoma, fibroma, fibromyoma, myxoma, and sarcoma, as well as combinations of these, have been recorded in the literature of the vas deferens. Such a tumor may arise from the coats of the vas itself or from the contiguous membranes of the spermatic cord. Either type of origin may result in a benign or precancerous growth, on the one hand, or in a malignant neoplasm, on the other.

While it appears that carcinoma never occurs as a primary tumor of the vas deferens, Thompson and Pilcher, in 1935, reported a case in a man 69 years of age in which a cancer of the prostate had extended secondarily to the left vas deferens, and in which microscopic examination revealed along its entire length a layer of tissue, contiguous with the muscular layer, which was of the same cellular structure as the hard, nodular tissue removed from the adenocarcinomatous prostate.

In 1901 Stoerk reported a case of rhabdomyoma (rhabomyosarcoma) of the vas that had produced metastases. Mönckeberg published a similar case in 1907, in a discussion of heterotopic mesodermal tumors of the lower end of the urogenital apparatus. This subject is treated in greater detail in the chapter on Surgical Diseases of the Spermatic Cord (page 746 (542)), to which the reader is referred.

CALCIFICATION OF THE VAS DEFERENS

Under some conditions the vas may become thickened, indurated, and even calcified at the level of the scrotum and epididymis as the result of disease or trauma. Tuberculosis, syphilis, or any other common inflammatory condition of the seminal vesicle and vas may be the forerunner of this rather unusual condition. It has also been observed without any history of inflammation in elderly men, as the result of senile changes. Oberlander, Chiari, and Dophéide have discussed this condition at some length, the last named author having reported 2 cases that came under his notice. Cross sections of the vas in one of Dophéide's cases showed the lumen of the vas to be markedly reduced in size, with the walls enormously thickened, their muscular elements having been completely replaced by calcareous substance which surrounded the lumen uniformly on all sides. Lowsley and Riaboff have recently reported a case of this kind, in which the ampullæ of both vasa had undergone complete calcification. These authors collected 31 cases from the literature.

ABSCESS OF THE VAS DEFERENS

Following vasitis and funiculitis, abscess of the vas may occasionally form. This may occur in two ways: (1) from rupture of the vas, and (2) from infection transmitted along the sheath of the vas. Rolnick has emphasized this avenue of infection of the vas, which is responsible for metastatic abscess of this tubular structure. This entity has also been recognized as a complication arising from vasotomy, vasectomy, and other surgical interference with the scrotal contents.

CYSTS OF THE VAS DEFERENS

Among congenital malformations of the vas deferens, cysts and diverticula, although rare, have been recorded in the literature. These small sacs form in the same way as aneurysms, and strongly resemble those commonly observed in the urethra and urinary bladder. It is obvious that these conditions may be the cause of chronic swelling and engorgement of the elements of the cord, which clinically may resemble many different pathological entities. Such cysts may only be discovered at operation or at post mortem, where they may be seen at any level of the lumen of the vas, but more frequently in the scrotal tract.

SYPHILIS OF THE VAS DEFERENS

Localized luetic manifestations of the vas may be one of the stages of the generalized infection of the disease. As a rule the affection is bilateral and there is usually evidence of orchi-epididymovasitis. Gumma of the vas, as well as of the testis and epididymis, while rare, has been reported in the literature.

OTHER PATHOLOGICAL CONDITIONS OF THE VAS DEFERENS

Stricture of the lumen of the vas, as the result of gonorrhea or trauma, is very commonly found and is in many cases responsible for sterility in the male. The stricture of the vas may be found in any part of the duct, but it is most commonly present either in the epididymal region or at the junction of the ampulla and seminal vesicle.

Impotence. By far the greatest number of cases of impotence have a localized pathology in the testes, urethra, prostate, seminal vesicles, or vasa deferentia. Seminal vesiculitis, either acute or chronic, by making orgasm painful, affects the libido, and so indirectly reduces the sexual potency of the individual. The changes in the posterior urethra and the verumontanitis resulting from chronic vesiculitis and prostatitis are responsible for a large class of sufferers from this condition. With the clearing up of these changes, many patients of this type are restored to full health and potency.

Wolbarst, in a study of 300 cases of impotence, has summarized his results as follows: A history of gonorrhea was admitted in 44 per cent. of cases, but denied in 56 per cent. Fifty-one per cent. admitted long-continued "withdrawal," excessively frequent coitus, frequent masturbation, or ungratified sexual desires. Thus gonorrhea and abnormal sex habits constituted the most frequent causes of impotence. Under urethroscopic examination, pathological changes were observed in 89 per cent. of cases with a gonorrheal history and in 77 per cent. of nongonorrheal cases with a history of abnormal sex living. In all cases, irrespective of the previous history, seminal vesiculitis was the invariable common factor. Pathology in the posterior urethra is not the cause of the impotence but reflects the primary pathological condition existing in the vesicles. Treatment must be directed to all possible etiological factors, but especially to the vesiculitis and the urethral pathology. In the vast majority of cases vasotomy is probably the most effective single therapeutic measure for the vesiculitis and the impotence. The prognosis is generally good if all etiological factors are accorded proper treatment. In this series, appreciable improvement to complete cure was attained in 77 per cent. of the total group.

Sterility. Stricture of the vasa or of the ejaculatory ducts is among the main causes of sterility in the male. Again, there may be malformations of the verumontanum or stricture of the urethra due to old gonorrheal infection. In vesiculitis, so much pus may be present that the spermatozoa cannot live in such a medium. If the inflammation is severe, they may be killed in transit, but even mild catarrh may so alter the quality of these secretions as to render spermatozoa infertile. Most frequent, however, as a cause of sterility are obstructions occurring at the level of the epididymis, which prevent the semen from even starting on its way. For these various obstructive conditions a number of operative procedures have been described in the literature, as we shall see in the section on surgical treatment. In addition to these conditions, localized in the upper spermatic tract, there are causes of sterility lying in the testes themselves, with which this article will not deal, the subject having been covered by another writer.

Filariasis and bilharziasis frequently attack the seminal vesicle in the tropics. The infection may travel along the lumen of the spermatic tract, the lymphatics, the blood stream, or the sheath of the vas to the structures in the lower spermatic tract, resulting in the formation of tropical hydrocele, spermatocele, and other conditions of the scrotum frequently observed in the warm countries.

Elephantiasis. The huge overgrowth in this disease is due to the blocking of the glands and lymphatics of the skin by the adult filariæ, which act as plugs. The skin is the only tissue directly concerned in this hypertrophy, but the vas, along with all the other elements of the cord, is dragged upon by the enormous weight, and as a result becomes lengthened downward, sometimes reaching half-way to the knee; in some cases it is also thickened with the other cord structures. The vas and testis usually remain healthy, however, and after operative removal of the elephantiasic mass may again function normally. Lymphangitis of the cord is said by Fayrer to be one of the earliest symptoms, and Esmarch and Kulenkampff cite Pruner as reporting that in a proportion of 1 case in 10 the cord and testis atrophy. Hydroceles are frequently found containing calcified filariæ. In a case mentioned by Canet in his thesis, microscopic examination of an epididymis revealed a decomposing female filaria surrounded by polymorphs, lymphocytes, and eosinophiles; no structures resembling the vas remained, the space occupied by the filariæ being surrounded by thick bands of fibrous tissue and dilated blood and lymph vessels. Where the vasa and testes are atrophied, it is impossible to say whether this is due to compression or to the long continence to which the deformity has condemned the patient.

The vas in relation to scrotal pathology. Concomitant or associated lesions of the vas are also found which are due to pathological conditions of the lower spermatic tract, as well as other lesions of the elements of the scrotal contents and of the scrotum itself. Among these conditions are teratoma testis, tumors of the epididymis or of the tunica vaginalis, tuberculosis and syphilis of the testis, epididymis, and scrotum; also hydrocele, hematocele, and varicocele, tumors of the cord, and torsion of the latter producing stricture or due to other metastatic lesions of the vas. Any one of these pathological states of the scrotum, which are commonly found in routine urological practice, may not only be the direct cause of associated pathology in the vas but may also lead to sexual impotence and sterility.

The vas in undescended testis. It is readily understood that the vas deferens is abnormally shortened in undescended testis and may thus be the site of pathological changes and absence of function. In most instances this terminates in atrophy and it may even be the forerunner of malignancy on the undescended side.

The vas in the presence of hernia. The vas deferens is affected in certain cases of inguinal or scrotal hernia in which the adhesions of the hernial sac pull down and exert pressure upon this delicate convoluted tube, particularly in cases of lipoma in which this solid tumor may involve even the very structure of the vas itself.

CHAPTER VII

RÔLE OF THE SEMINAL VESICLES AS FOCI OF INFECTION

THE DOCTRINE OF FOCAL INFECTION

It is only within recent years that the pathology of the seminal vesicles has been sufficiently understood for their significance as harborers of chronic focal infection to be appreciated and their etiological relation to many chronic systemic toxemias recognized. The seminal vesicles and prostate are, on the whole, more likely to be found involved in the dissemination of chronic infection in those cases of vesicular infection where urinary symptoms are absent, since here the presence of local symptoms of this kind indicates that there is drainage into the posterior urethra. It is more frequently in the absence of drainage that disturbances result in the development of metastatic infection or systemic toxemia, arising from a closed seminal vesicle that has been denied its normal outlet. Recognition of the rôle played by seminal vesicles in rheumatism and arthritis is one of the most notable discoveries made since the study of focal infections began. To Fuller belongs the credit for the first extensive research in this field (1912). In the same year Billings called attention to focal infection in its broader application in the etiology of general systemic disease. Squier, Lowsley, Mondor, and others have expressed the view that the milder strains of bacteria become localized in the joints. Von Lackum, Bumpus, and other workers of the Mayo Clinic have repeatedly demonstrated the importance of this theory. The truth of this conception of focal infection has been proved both clinically and by animal experimentation, and the importance of its establishment is today universally recognized in medical science.

SILENT INFECTION OF THE SEMINAL VESICLES

It is evident, therefore, that a silent or asymptomatic chronic seminal vesiculitis in a patient may be the direct cause of a distant lesion, not only in the genito-urinary tract but in any other system or organ of the bodily economy. A routine urological examination is essential to discover lesions that may be responsible

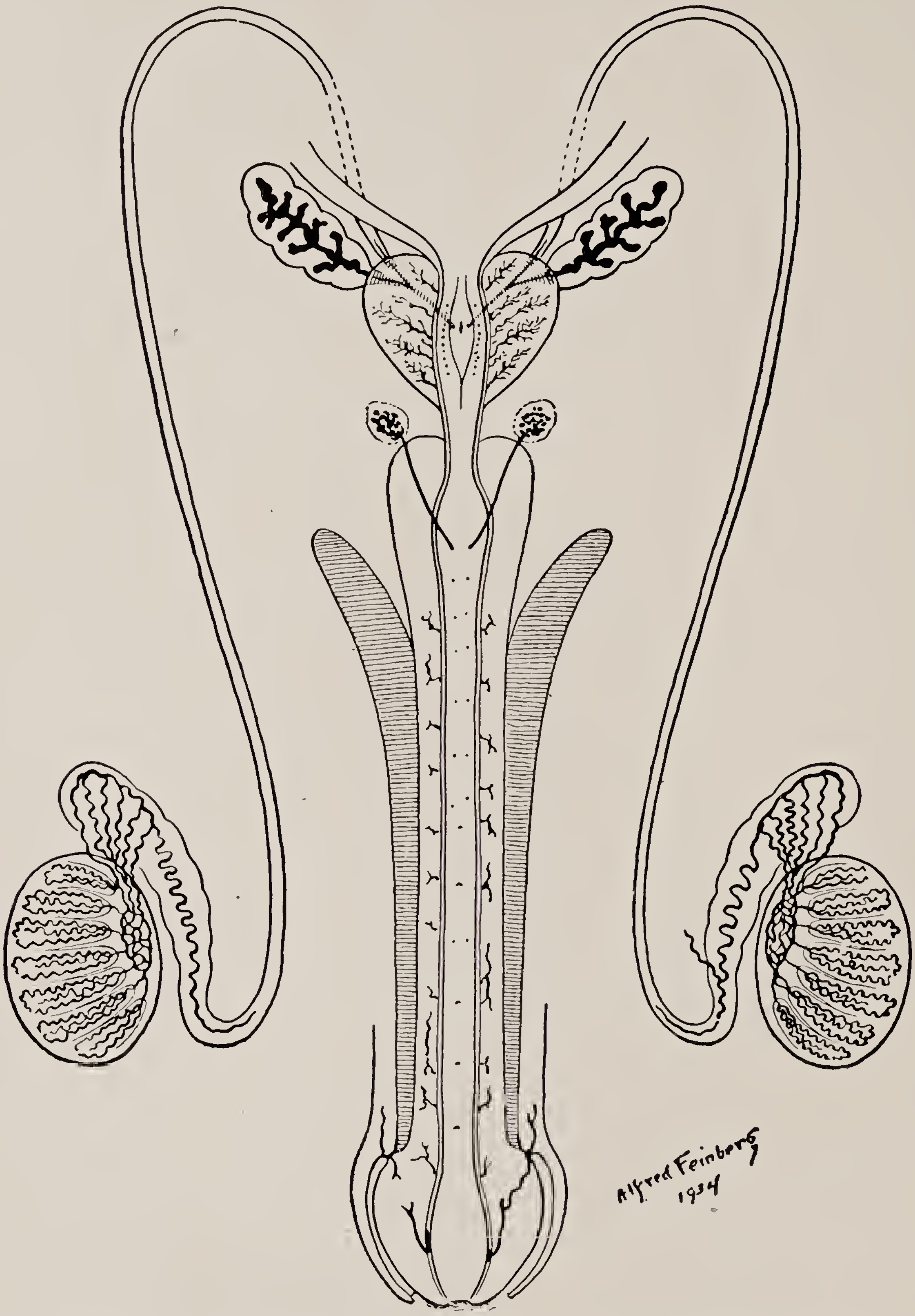


Fig. 19. Schematic drawing of the spermatic tract as a focus of infection. Note the enormous number of convolutions and diverticula that serve as potential storehouses for pyogenic bacteria. (Modified drawing after Papin.)

when morbid conditions exist in which the etiology is unknown. It is today a recognized fact that the seminal vesicles may be a focus of infection without giving any apparent sign or symptom, and that only on examination of the genito-urinary tract can the pathology of the condition be ascertained.

This conception of the vesicles and their adnexa as a potential source of infection is schematically illustrated in Figure 19.

A silent pathological condition of the kidney, such as we admittedly see in certain cases of tumors, stone, hydronephrosis, pyonephrosis, or occluded renal tuberculosis, bears a certain analogy to the pathological condition of the infected seminal vesicles. We know that the kidney may be diseased or even totally destroyed by an underlying pathological process, yet present no clinical symptoms, such condition being found only upon urological examination or at post mortem; and in just the same way an asymptomatic or silent infection may also be pursuing its course in the seminal vesicles unknown to the patient and all too frequently unsuspected by the general practitioner.

We have had occasion to see many such cases both in private practice and in the routine examination of patients at the Arthritis Clinic of the Hospital for Ruptured and Crippled, in New York, where patients are submitted to a thorough examination in an effort to eradicate all foci of infection.

Vesiculitis may be silent to both the doctor and the patient, and yet its clinicopathological manifestation be obvious and painful in distant parts of the organism, with nothing to indicate a relationship to the focus in the seminal vesicles from which it is derived.

Rheumatism. In chronic vesiculitis, the presence of large tracts of dense scar tissue around the vesicle, due to an associated perivesiculitis, results in constriction of the vesicle which both renders it incapable of emptying and also makes it less resistant to further infection. So-called gonorrheal rheumatism is due oftener to the secondary infection of the vesicle by other pyogenic bacteria than to the gonococcus itself, which most frequently, though not always, is the agent for the primary infection and prepares the soil for the secondary invaders. Opinions differ as to the length of the life cycle of the gonococcus and the duration of its presence in the seminal vesicles. It is known, however, that its stay is, as a rule, relatively brief, and that the secondary colonizations of other virulent microörganisms are responsible for the serious chronic inflammations that spread from the vesicle to other parts of the body, where they play the rôle of agents in the production of rheumatism. The gonococcus appears, in fact, to have a selective affinity for the genital tissues, and is only occasionally recovered from the joints. In the rheumatic group of infections, therefore, there is included that type in which there is a past history of an antecedent gonorrheal infection of the vesicle preceding the joint lesion. The relationship between an articular inflammation and such an infection is easily established when the former occurs at the height of an acute infection of the spermatic tract, but is more difficult to prove when some time has elapsed since the known period of infection. However, it is now well established that a focus of infection harbored within the seminal vesicles, if constricted by fibrous inflammatory changes and scar tissue, plays as definite a rôle in the production of rheumatic joint symptoms as do apical abscesses, diseased roots, or infected antrums and tonsils.

There is also another rheumatic group, characterized by primary nonspecific infection localized in the genital tract, in which examination reveals quite obviously the presence of a vivid focus of infection in the prostate and seminal vesicles, and in which the clinical rheumatic manifestations have been seen to subside upon local treatment. This nonspecific type of infection may be found at any age and is quite common even before puberty.

Arthritis. In any discussion of arthritis as the result of infection from inflammatory foci, it becomes necessary to consider the seminal vesicles and the prostate as a unit, on account of their very close anatomical association, for even if the infection starts in the prostate and is communicated secondarily to the seminal vesicles, it is this secondary infection of these small organs that makes them responsible for the metastatic infection. As a rule, it is not until after fibrous changes have occurred in the spermatic tract, affecting the prostate, ejaculatory ducts, ampullæ, and vasa, and interrupting the drainage of the seminal vesicles, that symptoms of arthritis make their appearance. The prostate is inflamed and boggy, the lumen of the vesicle becomes constricted or obliterated, its secretory epithelium destroyed, its walls infiltrated with leukocytes, and at length abscess formation provides the last requisite for the dissemination of the infection. The organisms present, when this chronic stage has been reached, are usually *Staphylococcus albus* and *aureus* and *Streptococcus hemolyticus;* next in order are the diphtheroid organisms, *Streptococcus viridans*, and colon bacilli. The relative frequency of these microörganisms is variously given, however, by different investigators; Hoffman, for example, finding the colon bacilli predominant and Nickel the streptococci.

In a study by Lowsley of 100 cases of arthritis discharged from Bellevue Hospital with a diagnosis of gonococcus infection of the joints, 66 per cent. admitted previous gonorrhea and 15 per cent. previous similar attacks of joint affection. The joints most frequently involved were, in their order, the knees, ankles, wrists, feet, hips, shoulders, hands, and elbows, together with a fair representation of affections of the spinal column, the heels, and the sternoclavicular joints. Muscles, tendons, and bones may all participate in the pathology of this arthritis of vesicular and prostatic origin. True osteitis was observed by Fuller in a case where the seminal vesicles were acutely inflamed; destruction of bone occurred in the tibia, followed by extension to the right radius. The prompt regression and complete cure of both acute and chronic arthritis after surgical removal of the seminal vesicles are satisfactory evidence of the causative rôle played by these organs in the arthritic condition, especially in view of the fact that these cures have been maintained years after the organs were removed. Increasing numbers of arthritis cases have of late years been seen everywhere; to such an extent that a special clinic has been created for this affection at the Hospital for the Ruptured and

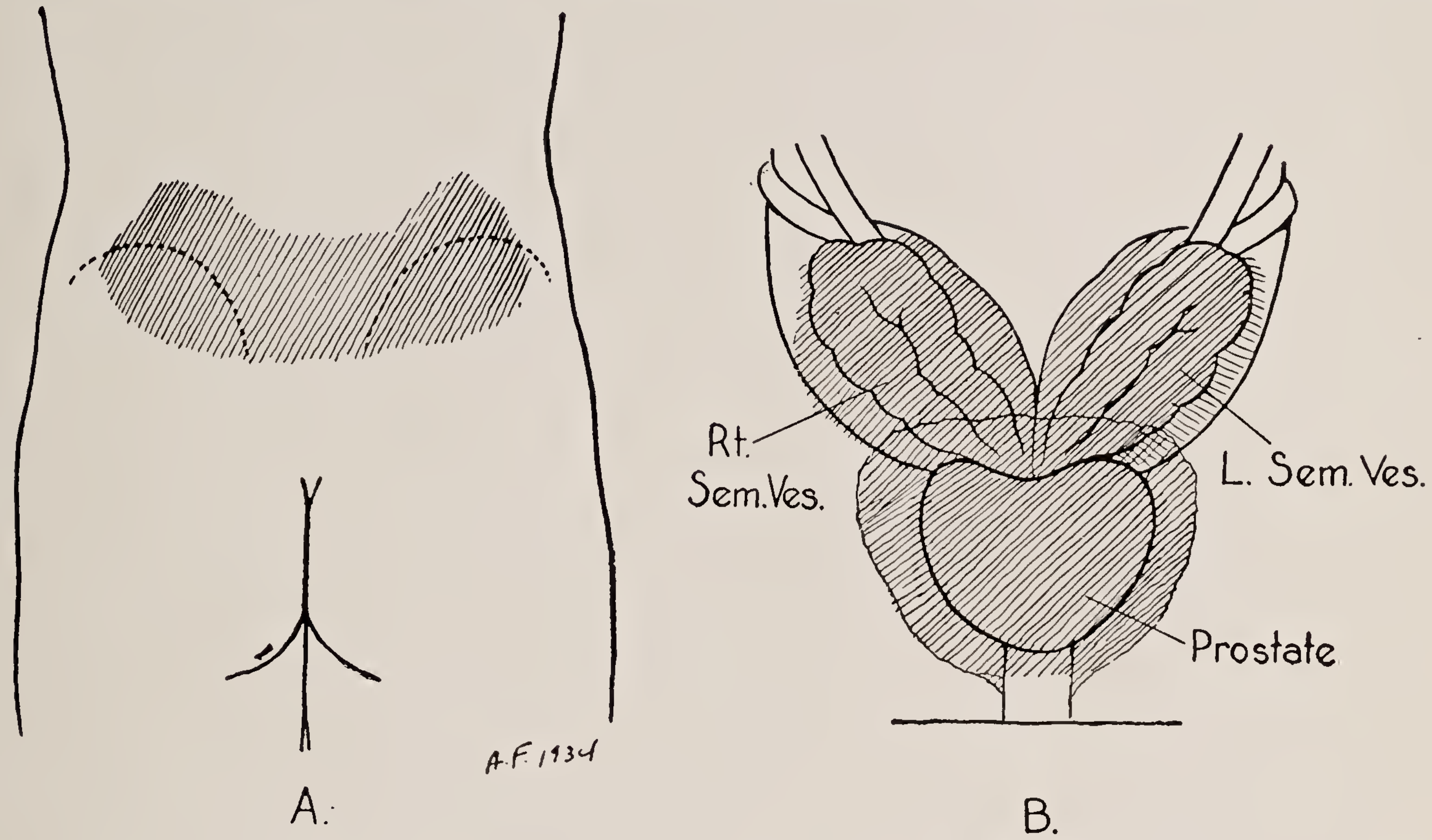


FIG. 20. This drawing illustrates why pain across the lower back is often mistaken for sciatica, lumbago, and orthopedic conditions of the lumbar spinal and sacroiliac synchondrosis, when, in reality, in most cases there is evidence of chronic seminal vesiculitis and prostatitis as its main cause.

Crippled, in New York, where many cases of this type are being treated for focal infection with excellent results.

Sciatica. An important relationship has also been noted between vesicular infection and certain cases of sciatica and sciatic neuralgia, since it has been established that many cases labeled chronic sciatica have their focal origin in an infected seminal vesicle or prostate.

Vesiculitis and backache. It has been observed that 75 per cent. of cases of backache in men are the result of seminal vesiculitis and prostatitis, due either to a disturbed sexual life or to the ravages of venereal disease. These disturbances cause backache through referred pains, a local fibrositis or arthritis having developed in the lumbosacral spine as the result of metastatic infection. It has been shown that the inflammatory overgrowth of fibrous elements in the tissues of the small of the back may entirely disappear with the removal of foci of infection in the spermatic tract, while neglected cases continue to form adhesions, with progressive thickening and contracture of the connective tissue, resulting in stiffness of the spinal tract affected. The pain is due to lack of drainage of the seminal vesicles, and is referred to the back by the sympathetic and parasympathetic innervation. (See Fig. 20.) It is characteristic of seminal vesicle backache that it is increased by pressure upon the vesicles, while the area of referred pain is not tender to the touch.

Osteomyelitis. It was possible to trace the origin of a case of osteomyelitis of the tibia, which had to be operated upon, directly to a dissemination of colon bacilli from the spermatic tract after a vasotomy had been performed with injection of collargol.

Ocular lesions. It has been estimated that fully 45 per cent. of all cases of acute iritis occur in individuals suffering from focal infections or as the result of unknown causes. The experiments of Rosenow in elective localization have proved that microörganisms from distant foci have a predilection for certain areas, among which are the eyes. De Schweinitz, in 1920, included inflammatory conditions of the seminal vesicles and prostate gland among the foci to which a certain number of cases of iritis are attributable. At the present time increasing numbers of cases of ocular disturbances of uncertain origin are being referred to urologists for a thorough examination of the urogenital tract. Typical cases of chronic endophthalmitis due to foci within the seminal vesicles are reaching the urologist, characterized by such conditions as floating vitreous opacities, changes in outline of the optic nerve, sclerosis of choroidal vessels, congestion of the macular region, and atrophy of the pigment epithelium of the retina — all frequently traceable to the toxic action of a distant focus in the seminal vesicles, which may be found, upon examination, to be distended and easily palpable, not emptying upon stripping, and associated with a prostate that is boggy and markedly enlarged. The vesiculoprostatic fluid in cases of this kind may contain 40 or more pus cells per high power field, and the culture may reveal innumerable colonies of pathogenic microörganisms. A case of this type was examined by the author for Dr. Berens, in which the culture of the prostatovesicular fluid showed multiple colonies of *Streptococcus nonhemolyticus* and *Staphylococcus aureus.* An autogenous vaccine of these organisms was made, which the patient received as a part of his routine urological treatment.

Other types of ocular lesions that have been linked up with seminal vesiculitis through the medium of a general toxemia, are iridocyclitis, corneal ulcer, conjunctivitis, both angular and phylctenular, blepharitis, episcleritis, dacryocystitis and retrobulbar neuritis. Improvement in some of these conditions, particularly iritis and iridocyclitis, when treatment of the vesicular focus was instituted, has been such a regular occurrence as to leave no room for doubt of the etiological relation existing.

Vesiculitis and cardiac lesions. The strain of streptococcus that produces rheumatic lesions was found by Rosenow to have an affinity for the endocardium and pericardium, and often for the myocardium as well. Billings, in 1914, as the result of studies carried out at Rush Medical College, reported that, among other organs responsible, the seminal vesicles had been found capable of serving as foci of infection in cases of malignant endocarditis, myocarditis, and valvular heart disease. Histological examination of the heart valves of certain animals inoculated with streptococci from the seminal vesicles showed embolic masses of these microorganisms in the terminal arteries; endothelial proliferation at the site of the embolus closed the vessel lumen. In chronic infectious endocarditis due to *Streptococcus viridans*, the infection is undoubtedly hematogenous. It was observed that the scar of healed endocarditis and valvulitis is often predisposing to further infection. This infectious agent grows most luxuriantly where there is a high oxygen content, such as is furnished in abundance by the circulating blood. It causes an abundant vegetative growth on the valves and endocardium, where it becomes immunized against the host and resists all forms of treatment addressed directly to the heart itself. Such conditions may, however, undergo striking improvement under methods directed not to the morbid organ but to the focus from which the infection entered the circulating blood. Examination of the seminal vesicles by rectal palpation will easily reveal the presence of such a focus if it exists in these organs, as is very frequently the case. Streitman reports that a number of cases of subacute endocarditis have come under his observation in which apparently a cure of the infectious process did result when focal infection was removed. He has also seen at least one case of angina pectoris disappear after focal infection was cleaned up, not to return after a period of 4 years.

The recognition and removal of such chronic foci in the vesicles is imperative as a preventive of progressive cardiac deterioration. Following removal of a focus in the vesicles, adequate general hygiene and urological treatment will strengthen the bodily defenses and may restore health if the morbid process in the heart is not too far advanced.

Vesiculitis and general toxemia. A group of cases exists, especially studied by Valverde, in which there is evidence of a toxemic syndrome, localized in the seminal vesicles as its focus; these throw toxic products into the blood stream, which result in a general intoxication of the organism. This syndrome is characterized by great prostration, fatigue, indisposition for work, loss of weight, impairment of memory, incapacity for mental effort, diminution of potency, premature ejaculation, loss of appetite, with serious trouble of the nervous system, ranging from simple irritability, with indefinite bad humor, to grave crises of neurasthenia with suicidal tendency. The specific dirty wax-color characteristic of grave intoxication is common to all these cases, — a pallor reflecting the changes occurring in the blood, especially in the corpuscles. In a group of 58 patients of this type, the gonococci were found in 42, while 16 were characterized by presence of streptococci, staphylococci, or colon bacilli. It is interesting to note that while it is rare to find the gonococcus in secretions where toxemia is absent, Valverde claims that he found them in 75 per cent. of these toxemic cases, implying a causal relationship.

According to Price, who studied the effect of focal infections within degenerating tissues and organs of the body, infections such as those from the seminal vesicles directly disturb the acid-base equilibrium of the blood and hence prevent the metabolic processes which remove from the organism the results of tissue reaction and of alimentation that has not been absorbed; the result is the formation of acid products which it is difficult for the organs to neutralize or which are neutralized at the expense of other vital processes, so that a direct disturbance of metabolic and catabolic processes is produced, resulting in the toxic picture described.

Men suffering with these symptoms of fatigue and exhausted vitality go from one place to another in search of relief. They are treated as simple cases of nervous exhaustion, and are not recognized as cases of focal infection of the seminal vesicles which is poisoning their entire nervous system and which can be completely relieved by measures directed to its source.

Septicemia. General complications resulting from chronic vesiculitis are in reality septicemic complications of the entire urethro-adnexal infection, since it is impossible to separate the different degrees of responsibility shared by the posterior urethra and its glands, the prostate, seminal vesicles, and the ampullæ, as foci of infection. There are cases, however, in which treatment addressed exclusively to the diseased vesicles has resulted in the clearing up of general systemic infections to a degree that left no doubt that the vesicles were the source of infection.

Neuroses and psychoses. Investigations within the last 15 years have demonstrated beyond a doubt that psychotic patients carry within their bodies multiple foci of infection, among which the seminal vesicles sometimes prove to be at the bottom of the psychotic condition. Among functional psychoses the most important factor has been found to be intracerebral, biochemical, cellular disturbance arising from circulating toxins that had their origin in chronic foci of infection. It is now known that in certain cases the seminal vesicles represent such foci. Excision of the vesicles resulted in cure or definite improvement of the psychosis in 48 per cent. of the series of 100 vesiculectomies performed by Gutierrez upon psychotic patients at the New Jersey State Hospital in 1923–1924. Kidd succeeded in curing certain cases of neurasthenia, impotence, and sterility by performing vasotomy to drain the seminal vesicles of their infective material.

Relapsing attacks of fever, rigors, and pyuria. Cases of this kind, in which the spermatic tract harbors the colon bacillus or streptococcus, have been known to disappear when vasostomy has cleaned up the tract and removed the infective agents.

Bacteriuria. It is not exceptional to find bacteriuria present during the course of a chronic suppurative vesiculitis, usually with the colon bacillus as the causative agent. There is reason to believe that in some of these cases the latent infection in the seminal vesicles and prostate has resulted in a lessened resistance on the part of the kidney, making it easy for microörganisms from extra-genital sources to find a congenial soil there.

Vesiculitis and nonspecific anterior urethritis. In routine daily urological practice many cases are seen in which the patient comes for examination having as his chief or only complaint a " morning drop " discharge, which is found upon examination to be of nonspecific origin. Moreover, these patients state definitely that they have never had venereal disease of any kind, or at any time, and yet, to their surprise and distress, they continue to suffer from this annoying symptom for no reason that they can assign. This " morning drop " is clinically manifested upon rising in the morning, or at the time of defecation, or, sometimes, upon the occasion of sexual excitement. Such a discharge is quite obviously due to the presence of a chronic or subacute seminal vesiculitis, and upon digital examination of this viscus the diagnosis is readily made. This condition is sometimes found associated with other nonspecific lesions of the urethra and verumontanum, as well as of the prostate.

Vesiculitis as a focus in ureteritis and nephritis. In any conditions that impede the natural outflow of urine it is relatively easy for infection to ascend from the bladder neck and gain a foothold in the ureter, whence it may reach the renal pelvis and even the kidney itself by the urogenous route, setting up successively a ureteritis, pyelitis, pyelonephritis, and nephritis. Such conditions of obstruction are met with in cases of stricture or kinking of the ureter, impeding the normal descent of the urine. It is quite generally accepted that urinary stasis encourages the spread of infection from the lower to the upper urinary tract. Hence, in cases of seminal vesiculitis, the infecting organisms, passing downward from the inflamed vesicle through the ejaculatory ducts and prostate, readily enter the bladder neck under these conditions and set up a cystitis, which is in its turn transmitted to the ureters, particularly in cases of the so-called " golf-hole " type of ureteral orifice where there is no sphincter and where, consequently, regurgitation or vesico-uretero-renal reflux occurs, resulting in the appearance of ureteritis, followed as a rule by infection of the kidney itself.

The microörganisms in the seminal vesicles may in some cases pass directly into the bladder wall at the trigone, and enter the ureter by direct contiguity. Here the infection is entirely secondary to a primary infection in the spermatic tract, to which the ureter readily falls a victim by reason of its anatomical relationship to the seminal vesicle. Under some circumstances the infection may pass first from its focus in the seminal vesicle to the ampulla of the vas deferens; invading the coatings of the wall of the vas, or, traveling along the sheath of the vas, it may then form adhesions with the ureter at the point where the latter crosses the vas and so work its way into the ureter by this direct route.

In addition to these routes, there is still another way by which infection from the seminal vesicles may reach the ureters and kidneys, namely by the lymphogenous route, being carried to these organs by the perivesicular lymph nodes with their rich network which favors the absorption of pyogenic bacteria and their toxins.

Once the infection has entered the ureter, by whatever route, the way lies open for an ascending infection to reach the kidney and lead to a pyelitis, nephritis, or pyelonephritis with all its associated systemic disturbances.

Nephrolithiasis in relation to seminal vesiculitis. The modern concept that focal infection is a prime etiological factor in the formation of renal and ureteral calculi is steadily gaining ground and is supported by the experimental production of renal and vesical stones by Rosenow, Hagner, Higgins, and other workers in this field. If this view be true, the seminal vesicles must take their place beside other structures known to act as foci of infection, and must bear their share of the responsibility for the formation of calculi in the urinary system. Bremerman, in 1915, expressed the view that renal calculi are related to a triplicity consisting of faulty metabolism, poor assimilation, and poor elimination. But in addition to these predisposing factors, which form the soil, he asserted that there must be some exciting element, such as inflammatory changes. He thought that inflammation is sufficient to start a process of crystallization in the presence of those elements in the urine which accompany faulty metabolism. Many other authors since then have agreed that the clearing up and removal of all foci ascertainable at the earliest possible moment is the principal step toward cure. The possibility of the prostate gland and seminal vesicles serving as such foci in nephrolithiasis has been clearly recognized. Bartlet, in an authoritative study of the subject, classified the possible routes of infection as (1) descending infection from the circulation in septicemic conditions, (2) ascending infection from a focus lower down in the urinary tract, and (3) transmission from neighboring organs by contiguity.

Under conditions of faulty metabolism, such as favor the formation of stones, the arrival within the kidney of virulent infective microörganisms from the seminal vesicles may furnish precisely the active element of inflammation necessary for the crystallization of mineral elements present within the urine. Strachstein observed that chronic prostatitis is frequently present in cases of nephrolithiasis, and we have already pointed out that when we are discussing focal infection, the prostate and seminal vesicles must be regarded as a single unit. Hence it is entirely reasonable to suppose that removal of foci within the seminal vesicles will have a beneficial effect upon the tendency of calculi to form within the kidneys, ureters, and bladder. Braasch, in fact, claims that only 3 per cent. of sufferers with renal calculi, from whom all foci have been removed, have a recurrence.

Silent lesions of the spermatic tract may, accordingly, serve as a source of constant or intermittent supply of pathogenic microörganisms producing metastatic infection in distant organs or a general toxemia affecting other systems adversely. Frequently a chronic infectious process is going on in the seminal vesicles or the vasa without any clearly localized symptoms in these organs, and yet the patient's system is suffering in some other tissue or organ as the result of this unrecognized process. Suspicion should be aroused whenever any patient who is under-weight and anemic, with lowered vitality and mental depression, comes with a complaint of a constant sense of fatigue, with dull pains in the lumbosacral or perineal region, or pain radiating down the legs which is not relieved by applications of heat or simple medication. In such cases a careful urological examination is clearly indicated, with rectal examination of the condition of the vesicles and prostate.

When this unrecognized infection has resulted in a distant arthritis, suitable treatment must be instituted immediately. In some cases puncture of the vas deferens results in prompt abatement of pain and swelling in the joints affected. If the vesicles are in an advanced stage of sclerosis, however, puncture or local treatment will not suffice, and vesiculectomy is called for. Where the arthritic changes are still recent, complete cure may be looked for;

where they are advanced, this is not to be expected, but even here a marked degree of improvement may be obtained.

At the Hospital for Ruptured and Crippled, in New York, Dr. R. Garfield Snyder, the Director of the Arthritis Clinic, has come to the conclusion that about 40 per cent. of cases of arthritis are of focal origin, and that, of the latter, about one-half are due to silent infection conveyed from the prostate and seminal vesicles, with only mild or no urinary symptoms being present. Systematic examination of the genito-urinary system is made in every case with a view to establishing a diagnosis and instituting treatment directed to the cause of the arthritic manifestations. Some of these cases are in children or in patients without venereal history, where there is no question of a gonorrheal origin; arthritis may exist as a result of seminal vesiculitis where no gonococcus has ever been present. The vesiculitis may arise from bacterial infections which have come down through the urinary tract following an acute infection of the kidneys; or it may be due to absorption of intestinal flora in which a colon bacillus infection has come from the colon and rectum, constituting a variety of the so-called Heitz-Boyer's enterorenal syndrome. The infecting organisms present are essentially the same as those found in the teeth, tonsils, sinuses, and colon. There is reason to believe that in some cases the seminal vesicles are not themselves the primary site of infection, but that focal infection starting from some of the above localizations has found its way to the genito-urinary system, and has there established mischievous secondary foci from which the infection is delivered to other parts of the system.

In all these silent infections, the urological history of the patient should be carefully looked into. It will then be found that a surprisingly large number of patients have an unrecognized vesiculitis and vasitis, after the clearing up of which a truly remarkable improvement in the distant manifestations of infection occurs.

CHAPTER VIII

DIAGNOSIS

Clinical exploration and taking of history. Whenever there is reason to suspect a pathological condition of the seminal vesicles, a careful history must be taken and a general physical examination carried out first of all, with a view to determining not only the nature of the pathology but also the acuteness or chronicity of the symptoms and the presence or absence of general or focal infection, especially of a tuberculous or gonorrheal nature. In addition to the routine physical exploration, the examining surgeon should note the state of the urine, the presence or absence of pulmonary symptoms, the degree of nervous sensitivity, and the presence, if any, of neurasthenia, fatigue, arthritic or rheumatoid pain, gastrointestinal disturbances, and urinary and genital symptoms. The genital and urinary history should be taken, and the usual three-glass urinary test made. The patient should be carefully questioned with reference to a history of pain and seminal colic, hemospermia, sterility, impotence, masturbation, and sexual neurasthenia.

Rectal examination. Diseased seminal vesicles are, as a rule, readily felt by the examining finger in the rectum, owing to the close proximity of these organs to the rectal wall. The patient should be asked to empty his bladder, after which this organ is refilled with boric solution. This serves a double purpose: a full bladder offers the necessary plane of resistance against which to make pressure in the course of examination, and the boric acid furnishes an antiseptic solution for the reception of the seminal fluid that may be expressed, which, if infected, is thus prevented from doing any harm. At the close of the examination the patient voids the solution, after which any secretions it may contain can be examined.

Position during rectal examination. A number of different positions are in use for this procedure, each having its own advantages. The two most generally used are the dorsal decubitus (gynecological position) and the erect standing position, with the trunk leaning forward from the hips and the patient's elbows supported on a table or high bed. In dorsal decubitus the thighs are separated, the knees flexed, and the pelvis slightly elevated on a cushion. The surgeon stands at the patient's right for the exploration of the right vesicle. The index finger of his right hand, protected by a rubber glove and well lubricated, is inserted with all possible gentleness; any roughness is liable to produce instantaneous muscular resistance and to frustrate the examination. To explore the left vesicle, he stands at the patient's left and uses his left index finger. A well-trained specialist can, however, with the right index finger feel all that is there. In youthful subjects the sphincter may offer some resistance despite the most careful handling. A normal seminal vesicle can seldom be felt unless in a state of unusual repletion. In a pathological state it is not uncommon for even the upper pole of the organ to be palpable; in some subjects, however, owing to obesity or to fear on the part of the patient, the finger may not succeed in reaching even the lower pole.

For this reason many surgeons prefer the upright position of Fuller, with knees rigid, legs slightly separated, while the rest of the body, from the hips up, is bent far forward and supported by the elbows placed on some hard surface. The surgeon's finger is inserted in the rectum and the patient invited to let his weight rest more or less upon the rest of the hand, held in fist fashion.

If the patient is in bed the rectal examination can be carried out by asking him to get up on his knees or to roll over on one side, or to open his legs while lying on his back. Although some of these positions are fatiguing for the patient, they enable the surgeon to reach his finger very high and to palpate the upper margin of the vesicles. If there is no pathological condition, he will feel only the smooth velvety surface of the unaltered vesicles, indistinguishable from the surrounding tissues. (See Fig. 21.)

Pathology revealed by rectal examination. In cases of disease, the rectal examination reveals the size, consistency, and sensibility of the vesicles under pressure, their mode of evacuation when expression is resorted to, and the lesions of the prostate that may be associated with the vesicular lesions. It discloses any induration, inflammation, nodulations, adhesions, neoplasms, tuberculosis, concretions, or other abnormalities that may be present.

Urethroscopy and examination of the verumontanum. In the presence of inflammatory conditions of the seminal vesicles, the endoscopic examination of the urethra gives important revelations. The posterior frenum of the verumontanum may be edematous and painful as the urethroscope reaches the prostatic fossette. In other cases the verumontanum is simply hypertrophied, with a corresponding displacement of the prostatic utricle and of the orifices of the ejaculatory ducts, as a result of chronic inflammation or of masturbation. In exaggerated cases of hypertrophy and inflammation, the axis of the verumontanum may have become deviated from vertical to oblique, and the organ may under some conditions become almost unrecognizable through inflammatory changes. When conditions of this kind are met with, they are a sure indication of corresponding disease of the seminal vesicles, of which Luys has, in fact, called the verumontanum the "antenna." It can be readily understood that prolonged passage of pus from the seminal vesicles is bound, ultimately, to cause serious injury to the walls of the verumontanum and the prostatic fossette by its septic content, resulting in infiltration, granulations, edema, polyps, cysts,

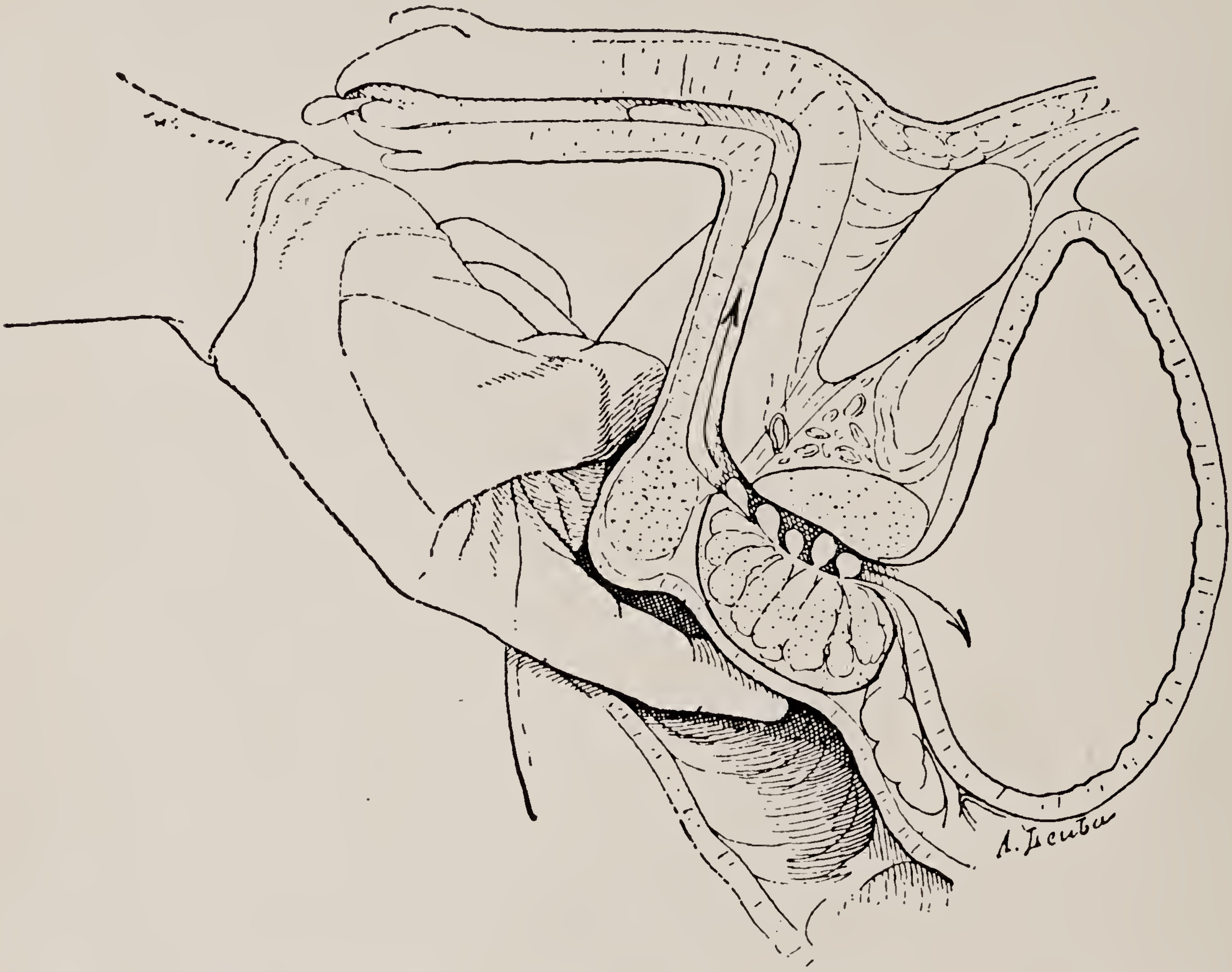


FIG. 21. Showing the mode of examination of the prostate and seminal vesicles by rectal palpation. After massage, the prostatovesicular fluid passes partly into the bladder and partly downward through the urethra, where it may be collected for examination. (After Papin, from Précis d'urologie, Paris, 1921.)

abscesses, and the like. Hence, urethroscopic examination of the verumontanum and the ejaculatory ducts is indispensable for the determination of disease of the seminal vesicles.

Cystoscopy. In view of the close relation of the seminal vesicles to the posterior wall of the bladder, cystoscopy may give useful information with reference to the vesicles since it is very easy for inflammation to pass through the wall of the bladder from the latter and vice versa. Localized cystitis has sometimes been found at precisely the part of the bladder wall against which the vesicles and ampullæ are situated, namely at the trigone. Also, in some cases it is possible to recognize a protuberance within the bladder corresponding to a greatly dilated and inflamed seminal vesicle. The lesion most commonly observed is trigonitis, sometimes with concomitant lesions of the ureteral orifices or other associated pathology of the bladder.

Catheterization of the ejaculatory ducts. Lavage of the ejaculatory ducts is carried out with a fine cannula introduced by means of a cysto-urethroscope, by a technic devised by Luys in 1913. Experiments by McCarthy, Ritter, and Klemperer have shown that when the catheter, inserted through the ejaculatory duct, reaches the bifurcation of the seminal vesicle and ampulla, it regularly takes the route of the former. For this they assign the following reasons:

(1) The ejaculatory duct is a direct continuation of the seminal vesicle.

(2) The wall of the seminal vesicle is less resistant and more distensible, because of its elastic tissue content, than that of the ampulla.

(3) The lumen of the ampulla is surrounded by a thick muscular wall and contains valves which tend to prevent the entrance of any fluid.

A poor technic, however, may result in introduction of the catheter into the ampulla, as when the catheter is pushed too far into the ejaculatory tube. Special catheters, needles, and cannulas, that prevent the instrument from taking the wrong course and which thus simplify the technic, have been devised by Luys, Young, Heitz-Boyer, Papin, Delzell, McCarthy, Ritter, Lowsley and Peterson, and others.

Microscopic examination of the prostatovesicular fluid. As has already been pointed out, it is difficult to obtain vesicular fluid unmixed with prostatic fluid. To obtain the former in as nearly a pure state as possible, Cabot's method is followed: The bladder is filled with boric acid solution and the prostate massaged, in order to empty it as far as possible. This fluid is expressed without touching the seminal vesicles; some of it will then occupy the urethra, some the bladder. The patient then urinates; the fluid voided is afterwards centrifuged, to secure the prostatic fluid. The bladder is again filled with boric acid solution, and now the vesicular fluid is expressed by massage of the vesicles. The patient again empties the bladder, and the fluid evacuated is examined for pus, blood, and casts.

When the inflammation around the ejaculatory ducts is very great, it may be impossible to obtain the vesicular secretion by massage. Under such conditions the following methods are available:

(1) Puncture of the seminal vesicle
    (*a*) By perineal route
    (*b*) By rectal route
(2) Aspiration
    (*a*) By Belfield's vasotomy
    (*b*) By endoscopic catheterization
(3) Collection of the secretion in a condom

Normal vesicular secretion. Normal vesicular secretion may be recognized by its gray color, viscous consistency, lack of odor, and the presence of abundant living spermatozoa, with occasional leukocytes and the usual number of epithelial cells.

Pathological vesicular secretion. In pathological vesicular secretion, the microscope reveals a brown to red or blackish color instead of gray, and abundance of leukocytes and desquamated epithelial cells, causing the fluid to lose its clarity and to become progressively thick, milky, and frankly purulent. As a rule, any secretion containing more than 3 to 5 pus cells per high power field is to be regarded as pathological and as giving evidence of the presence of vesiculitis or prostatovesiculitis, particularly if there is clumping of the pus cells. In addition to pus cells the fluid may contain blood. In many cases molds may be observed, — semi-solid fibrinous masses which retain the shape of the vesicular sacculations from which they have been expressed. These may be a centimeter or more in length, and form a thick network the meshes of which are filled with leukocytes, epithelial cells, pus cells, spermatozoa, and sometimes microbes. The spermatozoa under conditions of inflammation tend to be deformed, to lose their motility, and even to die.

In proportion to the degree and seriousness of the inflammation will be the number of pathological elements.

Spermo-culture. A minute bacterial examination of the vesicular secretion is indispensable. For this, simple microscopic examination is not sufficient. There must be a culture on a suitable medium, and to be dependable this must be repeated several times. Previous to making the culture there should be a complete urethroscopic examination of the mucosa of the entire urethra by a competent urologist. Besides the prostate, there are numerous Littré glands, Morgagni lacunæ, Cowper's glands, and follicles in the pendulous urethra that may harbor infection. If the complete integrity of the urethral mucosa is established, then it is clear that any pathogenic microörganisms found in the culture must come from the seminal vesicles. Experience shows that it is desirable to dilate the urethral canal with large béniqués previous to making the culture, since a negative bacteriological finding may thereby be turned into a positive one.

The secretion, or seminal fluid, should be collected under sterile precautions in a Petri dish. The semen is immediately sown in three tubes on a suitable culture medium, such as blood serum. After a 24-hour incubation it is examined under the microscope. The microörganisms most commonly found are the streptococcus, staphylococcus, pneumococcus, colon bacillus, and enterococcus, and, in specific cases, also the gonococcus and Koch's bacillus. Absence of the gonococcus is no proof, however, that this microbe was not the causative agent of the original infection since it is difficult to find this microörganism in old secretions, its existence being only ephemeral and yielding rapidly to other secondary infecting agents.

Laboratory tests. Besides the complement fixation test for gonorrhea and the culture medium for infection, animal inoculation should be done for tuberculosis, particularly into the guinea-pig. A complete routine urinalysis is always essential, as is also the three-glass test, to determine whether the urine is clear, hazy or cloudy, and whether it contains shreds apparent to the naked eye.

Roentgenography. Only in rare cases are the seminal vesicles visible in plain roentgenography. Certain calculi, favorably placed, may be recognized by this method, but they cannot be identified as vesicular by an anteroposterior exposure. The evidence given by a sagittal view is better, but even here stones of the fundus of the vesicle may be confused with stones in the juxtamural portion of the ureter, or with diverticular calculi. Nor can they be distinguished from stones of the prostatic urethra or calcifications in the prostate, unless they are themselves lateral. In some aged men it has been possible to observe calcification of the seminal-vesicle walls, as well as multiple stones in both vesicles. (See Fig. 25.)

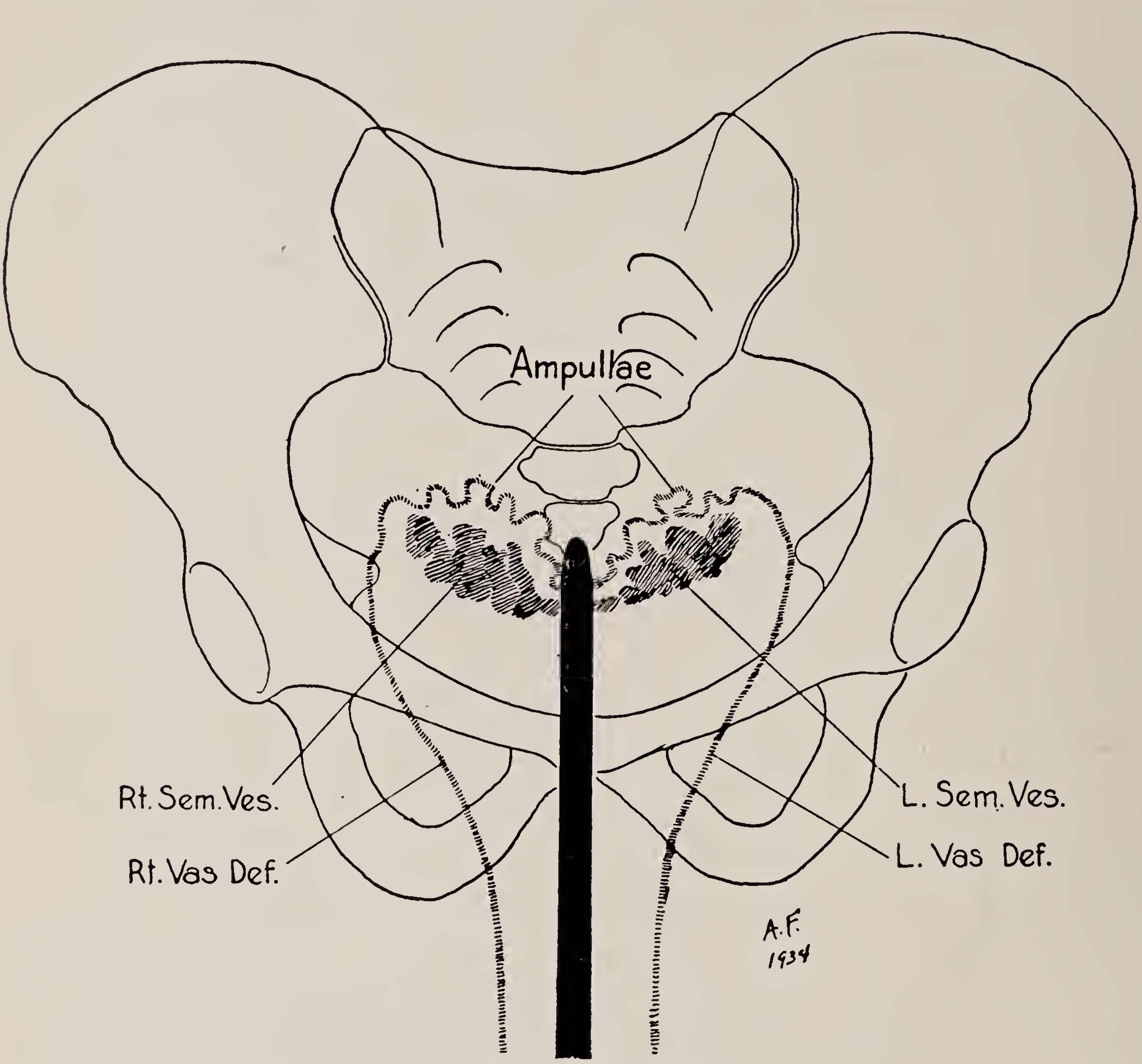


Fig. 22. Drawing from a vesiculogram showing the normal outline of the spermatic tract, as revealed by injection of an opaque medium, in which the vesicles, ampullæ and vasa deferentia can be traced down to the epididymes and testes.

Vesiculography. The discovery of the roentgenographic possibilities provided by the injection of an opaque substance into body cavities brought a new diagnostic means of great value into the field of urogenital surgery. As a result of this, vesiculography has become a routine urological method of examination. Five per cent. collargol, because of its therapeutic effectiveness, was at first used for vesiculography, but its images are not sufficiently sharp, and those from 10 per cent. collargol are purchased at the expense of too great irritation of the tissues. Sodium bromide is extensively used, but the best images today are those from iodized oils, especially lipiodol. In order to pass through so fine a tube as that of the spermatic tract, however, lipiodol must be diluted one-half with paraffin or amylal. Sodium iodide, 10 or 20 per cent., as in pyelography, is also commonly used. More recently, uroselectan or skiodan has been used with success. (See Figs. 22 and 27.)

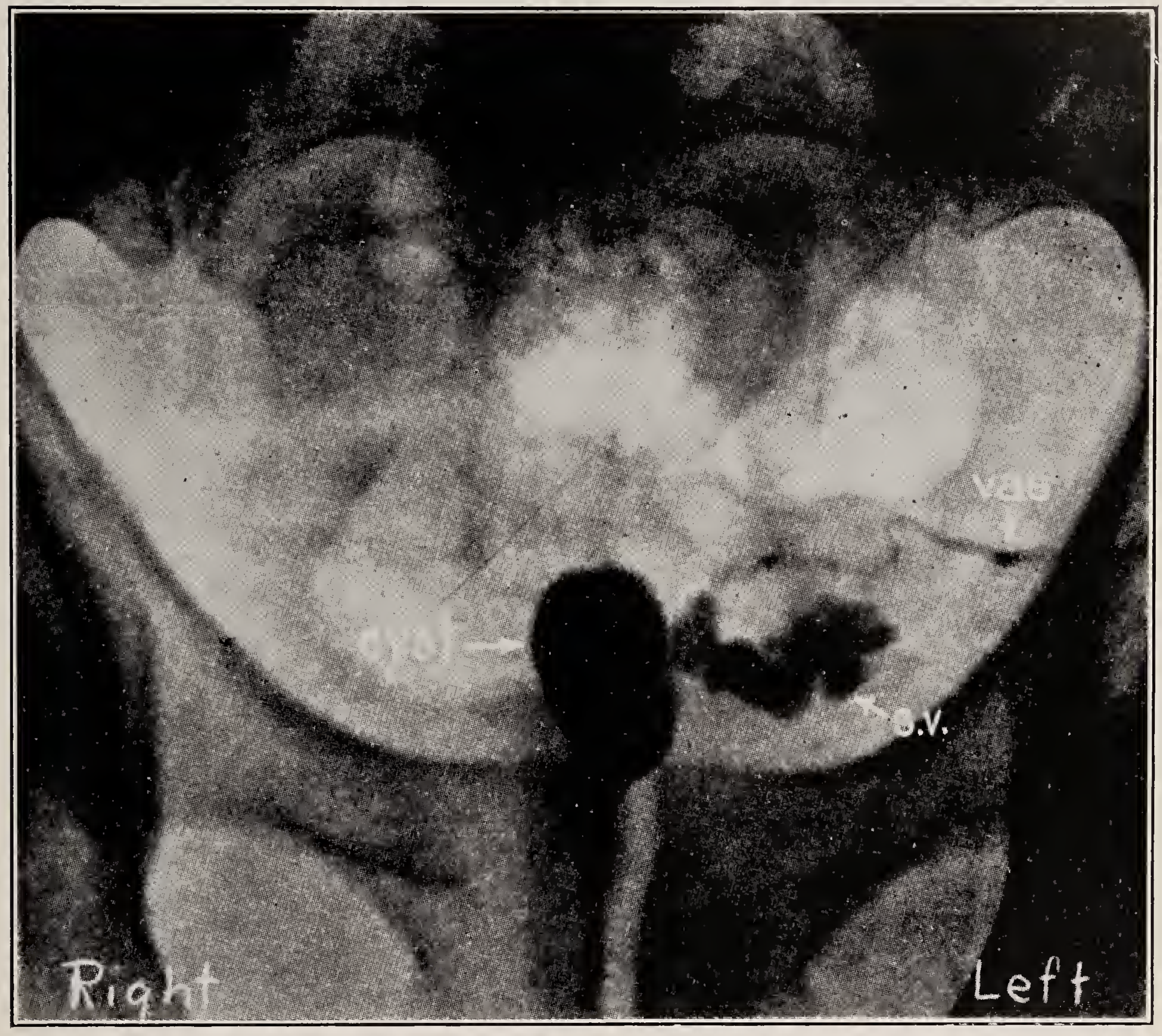


Fig. 23. Roentgenogram obtained after injecting the prostatic utricle with sodium iodide 15 per cent., revealing the unusual case of a cyst communicating with the left vesicle, ampulla, and vas deferens, thus constituting the pathological condition of a double anomaly, in which the prostatic utricle appears to be united or connected with the left ejaculatory duct. (From Young and Randall, *Surgery of the Prostate*, Chap. 3, p. 169, Nelson's Loose Leaf Surgery, 1928.)

Mode of injection of the opaque substance. The injection may be made through the ejaculatory duct or through the vas deferens, after surgical exposure of the latter. Injection through the ejaculatory duct is a delicate procedure, one that must always be done with particular care since it is possible to over-inject and spoil the

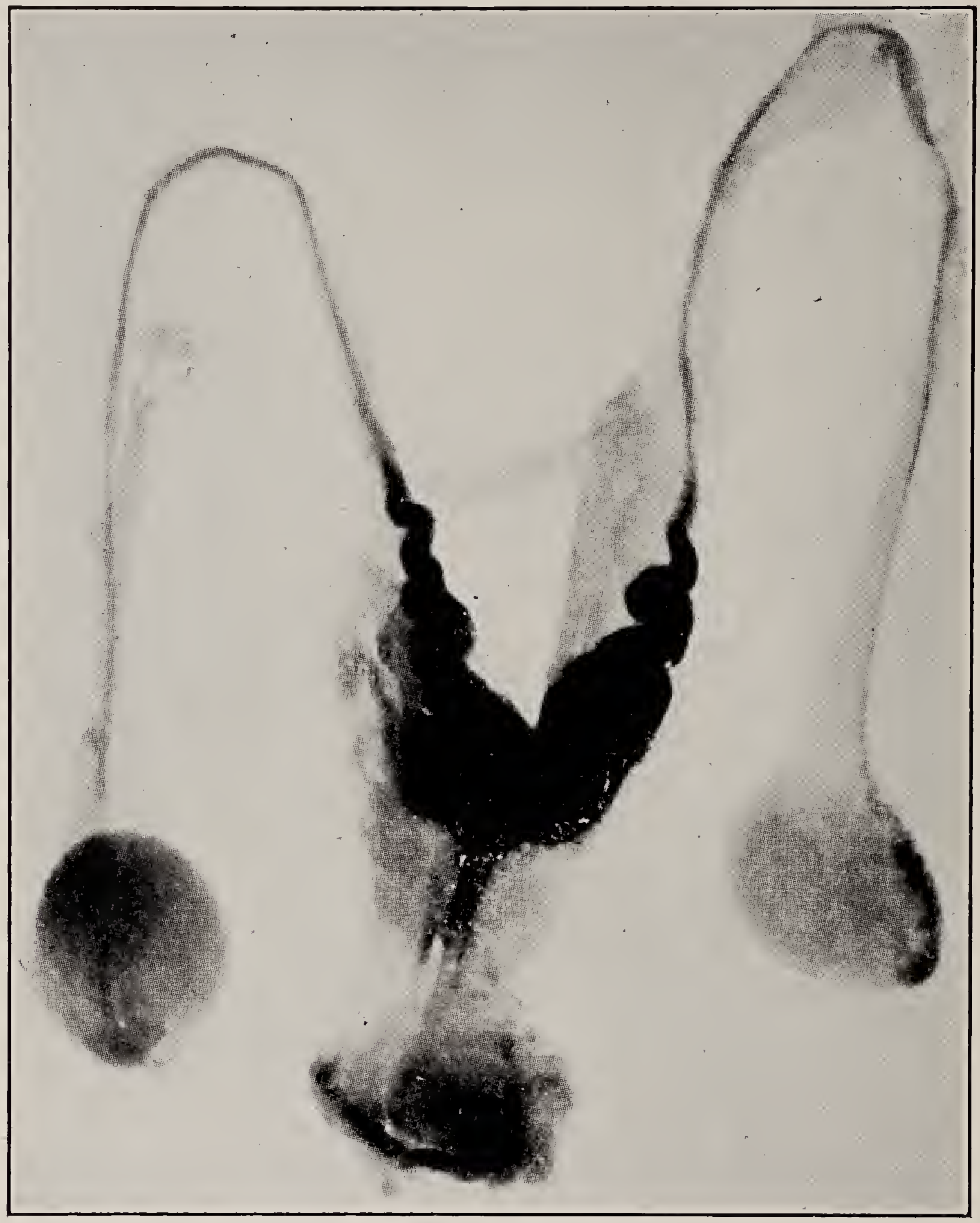


FIG. 24. Congenital absence of both seminal vesicles as revealed in the roentgenogram of an autopsy specimen after injection of 50 per cent. sodium iodide through both ejaculatory ducts. Note the complete absence of both vesicles with compensatory dilatation of the ampullæ, and also the clear outline of the vasa deferentia down to the epididymes and testes. (From Rolnick, Surgery, Gynecology and Obstetrics, p. 670, 1928.)

image or to fail to recognize the point of repletion beyond which rupture of the vesicle may occur. Injection through the vas, on the other hand, is an entirely safe procedure, since a large quantity of

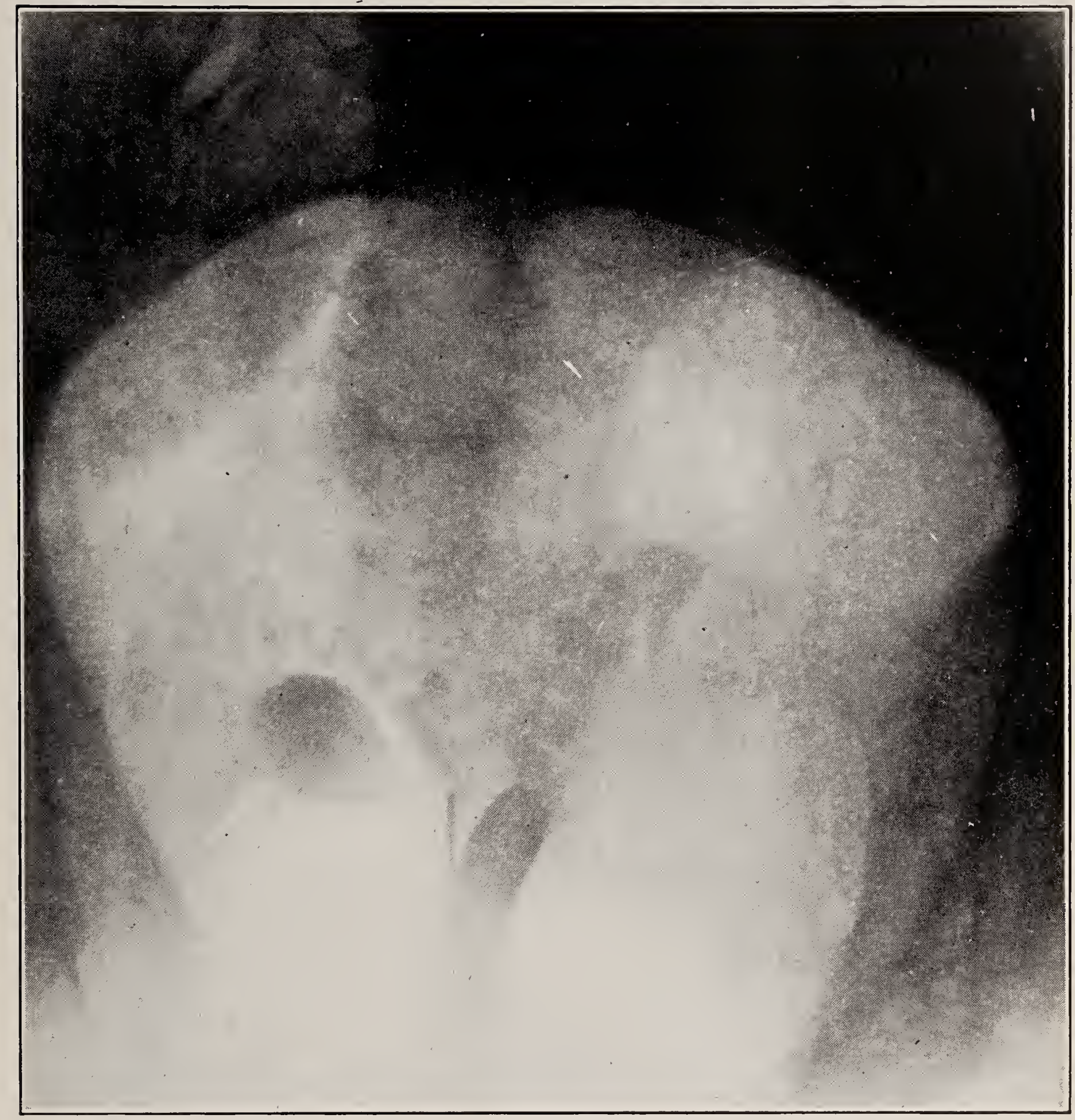


FIG. 25. Vesiculogram obtained by catheterization of the ejaculatory ducts by means of Delzell's needle, revealing a left seminal vesicle distended with chronic vesiculitis and an abscess of the right vesicle.

opaque fluid may be injected without fear of mishap, the excess running out through the ejaculatory duct and urethra or into the bladder, where it is harmless. The value of the vesiculogram may, however, be injured by an accumulation of opaque substance within the bladder, as this may be superimposed upon the view of the spermatic tract, in which case a poor image will result. With a moderate amount, such as 2 to 3 cc., this will not occur; the substance will not regurgitate until the vesicle is completely filled.

Injection through the prostatic utricle, when this is patent, may lead to the discovery of pathology and congenital anomalies of this minute pocular tract. (See Fig. 23.) In other words, utriculography for the purpose of diagnosis may yet find its correct indication, as Young, for example, has illustrated in the report of a case of cyst of the utricle, which was diagnosed by this method previous to operation.

Prostatography, accomplished by the injection of an opaque substance into the glandular tissue, may also be valuable for comparative diagnosis. Similarly, ampullography, or delineation of the ampulla, may be obtained by either of the two familiar methods of direct injection of the opaque substance into the vas deferens. This will serve to reveal strictures or any other pathological conditions that may be present not only in the vas but in the ampulla as well. In a case of congenital absence of both seminal vesicles discovered post mortem, true ampullo-vasography was obtained by injection of the opaque substance into the ejaculatory ducts (as seen in Fig. 24), thus serving to illustrate the presence of this rare anomaly.

Findings of vesiculography. By making a vesiculogram it is possible to learn the dimensions and form of the seminal vesicle and of the entire spermatic tract, and to discover the patency or nonpatency, particularly of the ampulla and vas deferens. The thoroughness with which the intricate windings of the tract are outlined emphasizes the efficacy of lavage of the vesicle. An experienced urologist is required, however, for the interpretation of the findings, which is a rather delicate matter. A complete familiarity with the great variety of appearances that the seminal vesicles and spermatic tract may present even in health is required in order to recognize the deformities that may arise under pathological conditions. Cases of carcinoma, tuberculosis, diverticula, abscess (see Fig. 25), vesiculitis, and perivesiculitis, and even vasitis and stricture of the vas have been diagnosed in many instances before operation, or post mortem, with the aid of vesiculograms.

Urethrography: Urethrocystography. In routine urethrography and urethrocystography, the opaque substance may occasionally reach the seminal vesicles by way of the ejaculatory ducts, and reveal a vesiculogram as an accidental finding. More rarely the entire spermatic tract may become visualized under these circumstances. The vesiculogram thus obtained is due to urethro-vesiculo-deferential reflux, which may occur in certain pathological conditions of the spermatic tract in which the sphincters of the ejaculatory ducts are either relaxed or have been completely lost. Under these conditions, the injection of an opaque substance through the urethra, designed to produce a urethrocystogram, may sometimes instead give valuable information about the seminal vesicles, due to reflux into a vesicle. This phenomenon may also occur

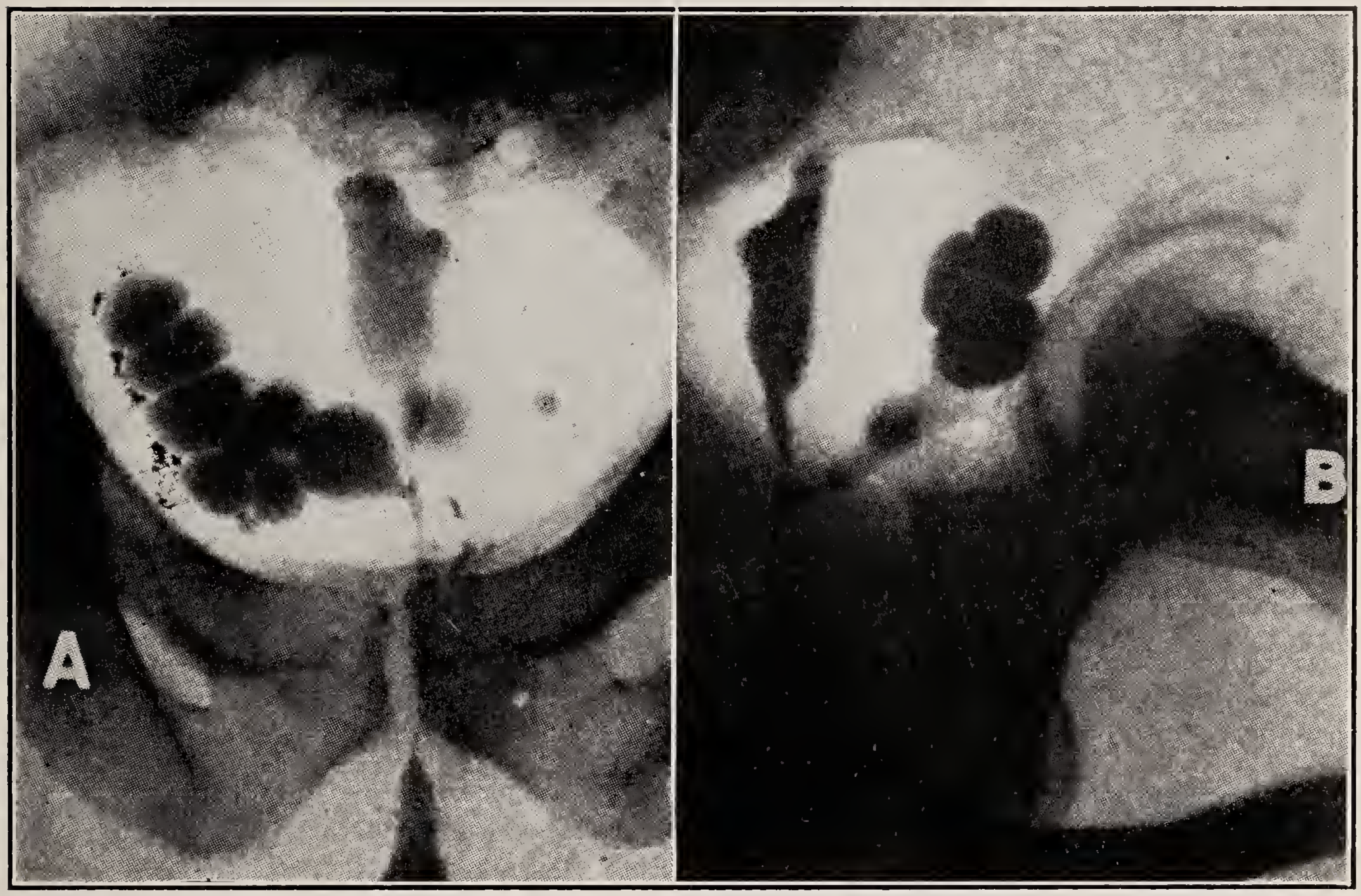


Fig. 26. Urethrogram revealing urethro-vesiculo-vaso-deferential reflux, with marked dilatation of the right seminal vesicle and of the right ampulla. The lipiodol injected through the urethra fills both the right vesicle and its ampulla.

A. In the anteroposterior view of the urethrogram, the right seminal vesicle and right ampulla are distended and distorted, disclosing the characteristic vesiculographic picture of tuberculosis of the spermatic tract.

B. In the lateral view, the urethrogram shows the point of union of the greatly dilated right vesicle and its ampulla. The history disclosed that this patient had been suffering from a chronic right tuberculous epididymitis of long standing, resulting in the formation of a scrotal abscess followed by a urinary fistula on the right side of the scrotum, evidently due to an opening of the vas deferens of the corresponding side. (Perves' case.)

during micturition after the bladder has been filled with opaque substance. The most common conditions in which this reflux is found are: (1) congenital malformations of the ejaculatory ducts in which the openings at the verumontanum are abnormally dilated, resembling the familiar "golf-hole" type of ureteral orifice, and (2) acquired lesions of the ejaculatory ducts, due to chronic inflammatory conditions following gonorrhea or tuberculosis, destructive lesions from fulguration of the verumontanum, or operations on the prostate, such as prostatectomy or transurethral resection.

Perves and Duvergey have recently collected from the literature 20 cases in which reflux of this type was revealed urethrocystographically. Reflux of urine into the spermatic tract is most likely to be observed in genital tuberculosis, particularly when there is evidence of vesiculitis, vasitis, prostatitis, or epididymitis of tuberculous origin, in which, owing to the tuberculous infection, the entire spermatic tract may be dilated, producing a sort of diverticulosis of the urinary tract. The presence of this reflux, when the urine is infected, may possibly explain the etiology of epididymitis following prostatectomy. The diagnostic value of the urethrovesiculogram that is obtained in such a case is evident. (See Fig. 26, A and B.)

CHAPTER IX

UROLOGICAL TREATMENT

Since the medical treatment of diseases of the spermatic tract, with its multiplicity of instrumentation and infinite variety of manual procedures, all of them requiring the care of the specialist, falls into the hands of the urological surgeon, it is impossible in practice to separate logically the urological from the surgical treatment, of which it properly constitutes a part. For purposes of description, however, the treatment of these conditions must be somewhat arbitrarily classified as urological and surgical.

We shall consider the urological treatment first, with the understanding that these procedures are, in reality, only preliminary steps leading up to the main work, which is always the surgical.

General hygiene. As a preliminary measure in all affections of the spermatic tract, expectant medical and urological treatment is indicated. First, the patient should be given absolute rest in bed, with a regimen of forced fluids, diet, and urinary antiseptics. Constipation, if present, must be corrected since it tends to cause an abnormal congestion of the seminal vesicles and all other pelvic organs. The administration of urinary antiseptics will have a soothing effect and will also serve to counteract infection that may reach the urethra in the urine and to acidify, neutralize, or alkalinize the urine, as the case may be. Hot rectal douches, enemas, or high colonic irrigations are given once a day with a view to relieving the painful congestion present in the seminal vesicles and prostate. The rectum is capable of tolerating a high degree of heat (110° to 120° F.) and it is possible to keep up a continuous circulation of moist heat about the inflamed area for any length of time that may be desired by means of a two-way tube. This prolonged application of moist heat tends to soften and liquefy the pent-up purulent secretion in the congested vesicular convolutions. Hot sitz baths and hot moist applications to the hypogastrium may also afford comfort. If the patient is allowed out of bed he should, under all conditions, wear a suspensory to relieve tension upon the spermatic tract. Under no circumstances may any sexual activity be permitted; if necessary, belladonna, atropin, tincture of hyoscyamus, or other suitable medication may be given for sedative purposes. Repose is the first and last word in the general hygiene of the inflamed seminal vesicles. It is, of course, obvious that in specific cases specific treatment must be given.

Chemotherapy. In dealing urologically with diseases and infections of the genito-urinary tract, a few of the most important urinary antiseptics now in use must be considered. It has been proved beyond a doubt by cultures and otherwise that the microörganisms that are chiefly responsible for the various types of infection in the genito-urinary tract can be eradicated by the use of the new sulfa-compounds. Recent studies and clinical experience in this field have demonstrated that these new sulfa-remedies are almost specific for certain microbic agents, such as the Neisserian gonococcus, the streptococcus, and the pneumococcus. When these substances are properly administered in combination with suitable urological treatment, the results obtained are truly spectacular. As a rule, the gonorrheal infection disappears within 5 to 10 days, the drugs acting upon these microörganisms in such a specific way as to bring about permanent cure.

The first drug of this group to be used was sulfanilamide. Then out of the magic wrought by this drug a line of other sulfa-compounds, somewhat less toxic and more efficacious, came into being, such as sulfapyridine, sulfathiazole, and sulfadiazine (2-sulfanilamidopyrimidine). In addition to these effective and germicidal drugs, which have come into general use in medicine and surgery, there are other urinary antiseptics of considerable value, such as mandelic acid salts (calcium or ammonium mandelate, alone or combined with methenamine). Other useful urinary antiseptics are pyridium, as a soothing medication for the genito-urinary mucosa; acriflavine, rivanol dextrose, and a host of others employed for instillations in various strengths.

All these drugs are of value, and should be kept in the armamentarium of the urologist for use in dealing with infections of the genito-urinary tract, always in combination with other urological treatment.

Massage of the seminal vesicles and prostate. The purpose of this procedure is to empty the seminal vesicles of their infected contents and, if possible, to establish drainage through the more or less obstructed ejaculatory ducts. The patient either assumes the knee-chest position or stands bent forward over a table of suitable height, his feet gripping the floor firmly to furnish adequate resistance. The surgeon's finger, which must be of sufficient length if massage is to be effective, is inserted in the rectum as far as it will reach, when, if it is long enough, the upper extremity of the vesicle of the side affected will be felt by the finger-tip above the two lobes of the prostate. With the end of the finger a firm pressure is now made from above downward, care being taken not to cause more pain than the patient can bear, and to regulate the pressure according to the extent of inflammation revealed on palpation. The massage should be gentle but firm, and never so vigorous as to cause bleeding; roughness may result in exacerbations of the vesicular inflammation, and frequently causes epididymitis. The prostate should always be massaged at the same time with the seminal vesicles.

Another method is that of bimanual massage. With the patient in the same position, the surgeon's other hand is placed upon the abdomen, where it makes firm pressure against the finger within the rectum. The vesicle thus receives pressure from both front and back, the apposing fingers compressing the vesicle from its apex downward toward the ejaculatory duct. In some cases this treatment gives considerable relief by effectively freeing the vesicle of its imprisoned contents. It is inadvisable and, in fact, contraindicated to massage in acute cases of vesiculitis; particularly is this true in tuberculosis or acute specific Neisserian infection, since, under such conditions, there is the possibility of disseminating the infection and even the danger of causing septicemia and other fatal complications. It is wiser, here, to postpone massage until the acute inflammation has subsided, or not to have recourse to it at all. Furthermore, pockets or diverticula that are badly drained by nature owing to their anatomical disposition, or with very marked fibrous adhesions, in which there are enormous concomitant prostatovesicular lesions with infiltration of the connective tissues, should not be subjected to massage. The simple, straight tubular systems in which massage may be useful appear to constitute only about one-third of the cases reaching the surgeon; in the others this method has little curative value.

Vibratory massage. An improvement over digital massage of the seminal vesicles has been described by Wolbarst, in the form of a pneumovibratory massage mechanically applied by the finger, which is introduced into the vibratory circuit arising from an apparatus capable of a speed of 8,000 revolutions per minute. The apparatus consists of an electric motor and air-pump for producing the oscillations, and an applicator for transmitting the latter to the finger-tip. The pump, which is mounted on one end of the motor housing, transmits these rapid oscillations to the air in the cylinder, from which they are conducted to the finger, clothed with a rubber cot, through a rubber tube 4 feet long, with practically no loss of intensity or frequency. The increased blood supply thus brought to the vesicles or to the prostate, as the case may be, undoubtedly contributes more than anything else to the utilization of the inherent curative resources of the patient in combating the infectious process. Other advantages of the apparatus are the complete absence of pain, the distinctly agreeable sensation of increased warmth in the region massaged, and the fact that vesicular or prostatic pus and secretion may thus be expressed with the least possible contact between the finger and the organ, the finger being simply moved about over the surface of the organ, without the slightest application of pressure.

Mechanical massage. Many instruments have been invented for massage of the vesicles and prostate, particularly in cases of obese individuals where the average surgeon's finger is too short to reach the vesicles. These instruments have proved to be of comparatively little efficacy, and, in view of the possibilities of traumatizing the bladder or rectal wall their use is not to be recommended if it can be avoided, especially since the instrument works in the dark while the well-trained index finger of the surgeon is itself a sort of eye capable of observing and controlling the conditions it is handling.

Bladder irrigation. Massage should always be accompanied by large antiseptic irrigations of sedative solutions to cleanse the urethra of the products evacuated during massage and to prevent reinfection of parts already cured. Owing to the intimate topographical relationship between the seminal vesicles and the bladder, through the intermediary of the verumontanum and prostatic urethra, infection from the vesicles easily passes into the bladder, and the bladder neck is almost invariably involved in infections of the vesicles. The patient should therefore be given urethrovesical irrigations of some antiseptic solution, such as silver nitrate 1:1000 to 1:5000, acriflavine 1:1000 to 1:5000, rivanol dextrose 1:5000, protargol, mercurochrome, or other weak antiseptic solution. Plain hot saline may be useful for soothing the inflamed bladder or urethral mucosa, or use may be made of a weak bichloride or potassium permanganate solution.

Posterior deep urethral instillation. To facilitate rapid drainage of the vesicular secretions, as well as those of the prostatic ducts, in an effort to relieve chronic inflammation, congestion, and infection in nonspecific vesiculitis, instillations of strong solutions of silver nitrate or argyrol into the deep urethra may be carried out with beneficial results, particularly in chronic vesicular disease. These routine treatments should be given two or three times a week, or as often as is necessary. In acute conditions they are too irritating in their effect, and it is better to substitute milder solutions, such as boric acid, acriflavine, or potassium permanganate. In acute specific urethritis, complicated with spermatocystitis, prostatitis, or epididymitis, the passage of any instrument, catheter, or instillator is contraindicated. A change of drug from time to time may be desirable to prevent the bacteria from becoming resistant to any one particular type of solution. Collargol, acriflavine, mercurochrome, silver salts, and various other antiseptics find their field here.

Dilatation of the posterior urethra with silk bougies, sounds, or béniqués, or with a Kollmann dilator, will serve to open the orifices of the ejaculatory ducts under conditions of stricture due to old chronic inflammation of the prostatic urethra, or to dilate potential strictures or stenosis of the lumen of this commonly infected conduit of the urethra. The Kollmann dilator, however, should not be used until sounds have already increased the size of this lumen; if used too soon, it will defeat its own end by inflicting injury upon the urethra.

Diathermy. Although frankly only a palliative measure, diathermy may often be applied advantageously as an adjuvant in cases of vesicular infection that prove refractory to massage. It may be applied by means of a posterior urethral or a rectal electrode, with the other electrode resting upon the perineum or hypogastrium. Under its influence the vesicles become less indurated and less painful, the effect of this carefully applied heat being to increase secretory and circulatory activity, thereby stimulating normal contractions and relieving tension due to engorgement. Diathermy is usually applied twice a week for about twenty minutes at a sitting, using a current of 600 to 800 milliamperes. Careful supervision is necessary to avoid fluctuations in the amperage, causing sudden changes in the electrical heat generated between the electrodes, which may result in forcible contractions of the perineal musculature, thereby bruising the already inflamed vesicular and perivesicular tissues.

Autogenous vaccines. Vaccines prepared from the bacterial elements taken from a semen culture have been utilized successfully in the hands of some workers in this field. Le Fur claimed 88 per cent. of cures with a single series of *piqûres*. There is no doubt that these vaccines increase the resistance of the blood to the infecting bacteria which have already passed through the mucosa into the tissues, where they are not reached by irrigations. Thomson, by a special method, succeeded in producing a gonococcus vaccine which can be given in an initial dosage of 20,000,000 and increased afterward to 100,000,000 germs. It is the most effective vaccine ever produced to combat the gonococcus. His method, in a general way, is the substitution of mechanical means of detoxication for chemical disintegration of germs.

Hormone therapy. The use of gonadotropic hormone therapy has received much attention within the last decade as a mode of treatment for glandular disturbances in both the male and the female.

In some cases of sterility and impotence, routine urological treatment, combined with intramuscular injection of male hormone in the form of testosterone propionate in various dosage, has resulted in cure or marked improvement of these conditions. In the routine examination of the specimens collected after prostatovesicular massage, there have been many instances in which very few spermatozoa were found previous to treatment, and those present often possessed but poor motility and showed various deformities, or were atrophic or even dead. In some of these cases, after a few months of the combined urological and glandular treatment, microscopic examination has revealed a distinct gain in motility, size, and number of the spermatozoa. As it is sometimes necessary to continue these treatments over a long period of time, it has been found more convenient now to administer male hormone orally in the form of methyltestosterone.

These hormones also correct metabolic dysfunction of the seminal vesicle and prostate gland, definitely softening and shrinking these organs and bringing them down to a normal level. In some individuals suffering from benign prostatic hypertrophy with a certain amount of residual urine and marked dysuria, the use of these new substances has been beneficial in restoring normal function, when combined with urological treatment.

It would be a mistake to regard male hormone treatment as an adequate substitute for surgical intervention when there is definite indication for the use of operative measures in surgical pathological conditions of the prostate and seminal vesicles. It may, however, be a useful adjunct in the preoperative and postoperative treatment of such conditions.

The female hormone, or estrogenic substance, in the form of α-estradiol dipropionate or diethyl-stilbestrol, which has been used for sterility in the female, also has its application in the male, for prostatovesicular disturbances, and especially in carcinoma of the prostate, and seminal vesicles, in which castration is performed for control of the tumor and its metastases. In such cases, it is indicated both before and after castration, for maintenance of the level of the testicular hormones after castration has been accomplished. These estrogenic substances may be administered either orally or intramuscularly. They are capable of producing all the physiological effects of natural estrogen, especially after castration.

Some of these forms of endocrine therapy may also be useful in cryptorchidism, to aid in the descent of the testis to its normal position, as well as to encourage its full development. If, however, this treatment fails to bring down the testis within a reasonable length of time, resort should be had to surgery. Postoperative results in such cases are greatly improved by this preliminary hormone treatment. Hormone therapy is, accordingly, a valuable adjunct to surgery, both preoperatively and postoperatively.

Urethroscopic applications to the verumontanum. Topical applications to the posterior urethra and specifically to the verumontanum, consisting of silver nitrate in gradually increasing strength (from 1 to 40 per cent.), or a solution of phenol and glycerine (50 per cent.), tend to open the ejaculatory ducts, to reduce bulbous edema, and, by improving the condition of the urethra, to give wider drainage to the seminal vesicles. They are of great importance as a preliminary procedure, before catheterization of the ducts, in cases where the verumontanum is severely infected and swollen with inflammation, since the clearing up of these conditions is necessary to make catheterization possible.

Fulguration of the verumontanum. In some instances the verumontanum is so distorted and deformed from long-standing inflammation of the prostatic urethra that the ejaculatory-duct orifices cannot be discovered without previous cauterization or fulguration of the verumontanum. When the urethroscope or the urethrocystoscope reveals that such is the case, as, for instance, when a polyp or chronic ulceration has completely transformed the normal relations of this structure, recourse should be had to endoscopic treatment with some one of the various fulgurating instruments now in common use. An electrode should be gently applied to the surface of the organ, with proper care not to destroy it too deeply while making the application. In carrying out an endoscopic prostatic resection, it has been demonstrated by Caulk, Bransford Lewis, Lowsley, Bumpus, Gutierrez, Ockerblad, and others that when the verumontanum has been too completely fulgurated, destroyed, or shaved away, this has in many instances resulted in urinary incontinence and other painful complications.

Catheterization of the ejaculatory ducts. The routine catheterization of the ejaculatory ducts for the purpose of irrigating and draining the seminal vesicles should be considered just as essential a procedure in the treatment of disease of the seminal vesicles and spermatic tract as is the routine catheterization of the ureters and kidney pelves in affections of the kidneys. It has the advantage over vasopuncture that it does not require a surgical incision and can be repeated as often as necessary, while the latter is done once and for all. It has, on the other hand, a disadvantage of its own, in that it requires patency of the ejaculatory ducts for its successful performance. We have already seen that difficulty is frequently encountered in finding the duct orifices when the verumontanum is severely inflamed or ulcerated; in some cases the pathological changes are so great that this difficulty proves actually insurmountable. When, however, it has been made possible, by urethroscopic treatments, to clean up the verumontanum and make the duct orifices perfectly visible, this endoscopic lavage of the seminal vesicles is easily accomplished, and is an invaluable form of treatment.

Since the technic of catheterizing the ejaculatory ducts has been perfected, and since urologists no longer look upon it as difficult and impracticable, its importance has become generally recognized. Clinical experience, controlled by repeated vesiculography, shows that the therapeutic factor is the mechanical dilatation of the ducts rather than the injection of antiseptic solutions. It has been a common observation that vesicles treated by dilatation alone have regained their normal contours just as well as those that were injected. In vesicles adequately drained by catheterization of the ejaculatory ducts, not only has moderate infection cleared up, with relief of urinary disturbances, but even chronic vesicular abscesses, with large pus pockets, have been emptied and closed up. Herbst

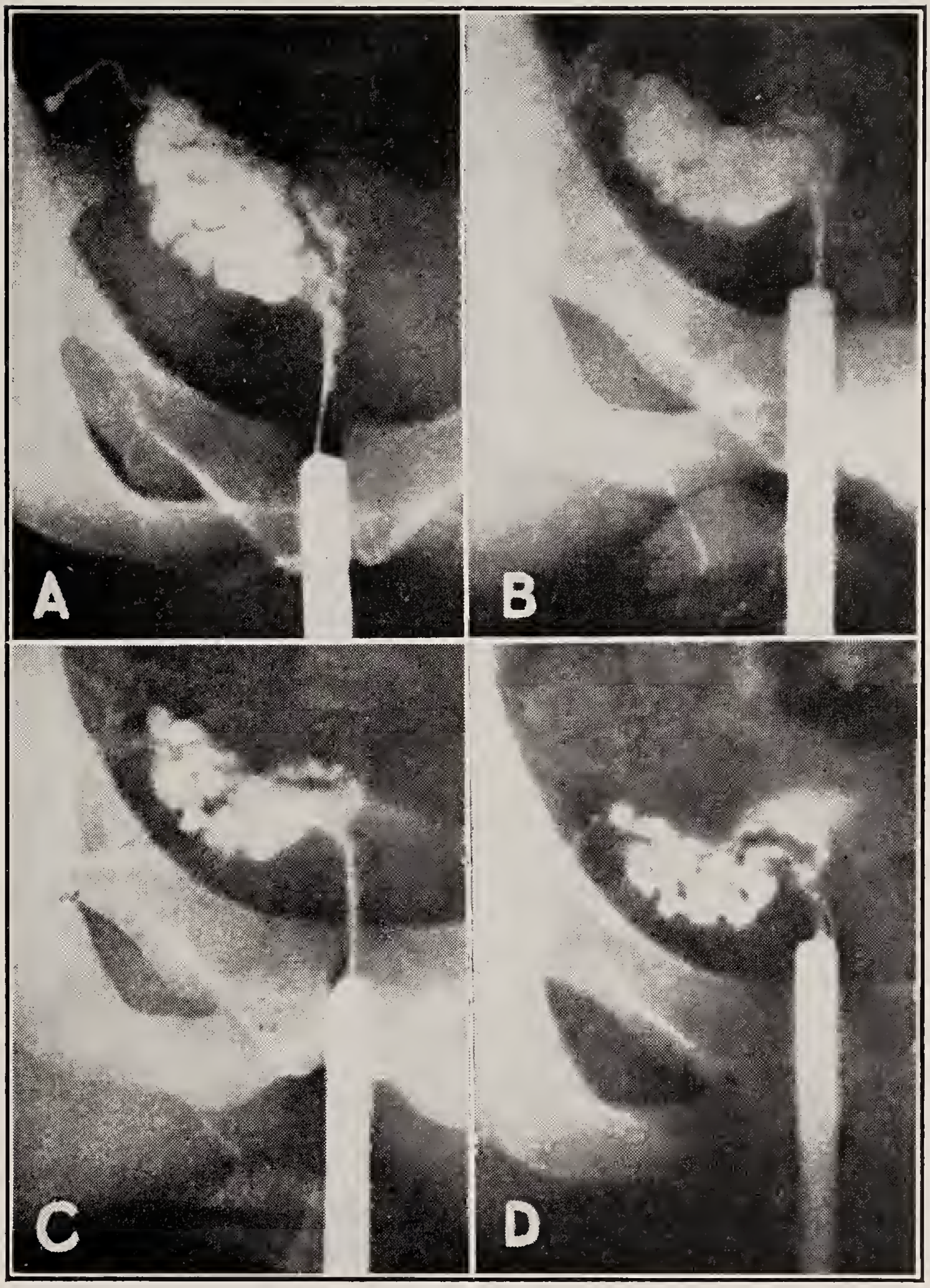


FIG. 27. Right vesiculogram, with delineation of right seminal vesicle, ampulla, and vas deferens. The opaque substance injected by catheterization of the right ejaculatory duct discloses dilatation of the chronically inflamed viscus, which, after several treatments by catheterization and lavage, has been reduced to its normal size, with relief of symptoms.

A. The right seminal vesicle and its ampulla are seen to be dilated, with a saccular, chronic catarrh of the vesicle.
B. The same, after lavage of the seminal vesicle, indicating shrinkage of the vesicle and improvement in drainage.
C.–D. The same case after several treatments by catheterization and lavage, indicating improvement in the structural condition of the right vesicle, which has been reduced to its normal size, with subsidence of symptoms. (Peterson's case.)

and Merrick drew attention to the beneficial effect that such drainage may have even upon perivesiculitis. They reported a case in which an ischiorectal abscess, operated upon 6 times but always returning, had been successfully eradicated by catheterization of the ejaculatory ducts.

Indications and contraindications. Apart from its usefulness for lavage of the vesicles, this catheterization has its indications for dilatation of the ejaculatory ducts in cases of stenosis and stricture, and in cases where the ejaculations are bloody, weak, or insufficient, as well as for sterility, which may be due to obliteration of the ducts. It is contraindicated (1) in the course of acute inflammations of the anterior or posterior urethra, and (2) when the verumontanum presents such grave pathological changes that the ejaculatory ducts cannot be found.

Technic of catheterization of the ducts. After a preliminary irrigation of the bladder and urethra, the urethroscope is introduced into the urethra up to the prostatic fossette. Several instrumental devices have been invented for making the catheter take the same relative course through the verumontanum as that taken by the ejaculatory duct itself. In the original technic, as devised by Luys, a very fine steel stylet, of which six sizes are available, with an elbow at its proximal end constituting the handle, is directed horizontally along the lower wall of the urethroscope and is introduced under full vision into the orifice of the duct, just as one would introduce a ureteral catheter into a ureter. By a few lateral and vertical movements the catheter is easily made to open the orifice, after which a slight outward movement of the handle permits it to enter within the duct a little obliquely for 1 to 3 cm., as shown on a graduated indicator on the stylet. At this point a slight resistance is felt: it is generally due to the arrival of the catheter at the spur separating the ampulla of the vas deferens from the seminal vesicle. Experience shows that the injection always, under proper technic, passes into the vesicle and not into the vas. McCarthy, Ritter, and Klemperer, as already stated, have recently shown that there are reasons for this: (1) The ejaculatory duct is a direct continuation of the seminal vesicle; (2) the wall of the vesicle, containing elastic tissue, is less resistant than that of the vas; (3) the lumen of the ampulla is surrounded by a thick muscular wall; (4) the latter lumen contains valves which tend to obstruct the entrance of fluid into the vas. For the injection to enter the vas, the catheter would have to be pushed too far into the ejaculatory duct, an eventuality made impossible by a stop device attached to the handle. Cases of orchitis or epididymitis that have occasionally resulted from catheterization have been due to the use of a sound without this protective device.

Technic of lavage of the vesicles. Using a plain urethroscopic tube, with its light attached at the end, or a urethrocystoscope, or panendoscope, the catheter is introduced into the ejaculatory duct. In the event of any bleeding which would conceal the orifice from view, tampons containing adrenaline-cocaine solution must be introduced to control it. When the catheter is safely within the duct, an assistant attaches a syringe, containing collargol or argyrol, to the catheter, and 5 to 10 cc. is injected. Under vision it is easy to control the entrance of the fluid into the duct and the vesicle, and to make sure that it does not flow back into the verumontanum or prostatic urethra. The technic is easy, provided the ducts are patent.

Puncture of the seminal vesicle. This procedure, originally carried out by Kocher, has been occasionally used since by others. It may be done *transrectally* (Taylor) or *perineally* (Ingall). In some cases, the purpose has been only to drain; in others, medicaments have been introduced. In addition, the puncture may be accomplished with an aspirating needle especially devised for the removal of tissue for biopsy purposes. The transrectal puncture is difficult to make aseptically, but if the vesicle is very large it is relatively easy to do under guidance of the finger. Evacuation, however, tends to be insufficient, the reflux of irritant solutions is not without its disadvantages, and epididymitis is frequent. Perineal puncture, on the other hand, is less septic but more difficult, running the risk of puncturing the rectum, bladder, or peritoneum under guidance of only a finger in the rectum. It too exposes the patient to epididymitis and, like the transperitoneal puncture, constitutes an incomplete treatment.

Radiotherapy. Since carcinoma of the vesicles and vasa has been met almost solely as a secondary condition, arising from the prostate and contiguous structures, the use of surgical measures here holds out little permanent hope for the patient, particularly in view of the fact that patients are as a rule not referred for examination until extensive metastases have already developed. It appears probable that radiotherapy offers better prospects in such cases, and at less expense than the radical operations. Young, Marion, Jeanbrau, Papin, Barringer, Herbst, Deming, Chauvin, and others have reported encouraging results by means of radium, radium puncture, radon seeds, and deep x-ray applied as uniformly as possible over the invaded territory. Chauvin is a partisan of small doses of radium left in place for 10 days. Young, on the other hand, uses a complicated technic with large doses over briefer periods. Deming obtained functional improvement of the urinary symptoms in 75 per cent. of cases attended by dysuria. The results are purely local, and one cannot hope to combat regional extensions or metastases by this means. Bumpus observed in his report of the Mayo Clinic that none of these cases attain the five-year limit of life following treatment.

Fractional doses of radiation and deep x-ray before and after radical operations for tumors of the spermatic tract have been advocated and used by Barringer, Dean, Ferguson, Ewing, and other writers, who claim beneficial results in malignant tumors of the prostate, testis, epididymis, spermatic cord, and vas deferens. In the great majority of cases the lesions are discovered too late for any effective permanent result. However, deep x-ray frequently gives considerable relief in cases in which great pain is present as the result of disseminated metastases making pressure upon nerves.

Application of deep x-ray and radium treatment have been helpful in the treatment of sarcoma or lymphosarcoma of the vesicle, prostate, and retrovesical space when the tumor mass is too extensive for radical operation. These methods not only relieve pain, dysuria, and other urinary symptoms but also reduce the size of the tumor mass, control to a certain extent the spread of metastases, and, in some instances, build up the general resistance of the patient.

CHAPTER X

OPERATIONS UPON THE SEMINAL VESICLES

Much progress has been made in the last quarter of a century with reference to recognition of the definite indications for surgical intervention upon the seminal vesicles and the entire spermatic tract, and also with reference to the development of a surgical technic for attacking pathology of the vesicles and solving the various surgical problems that may be presented in the spermatic tract.

Operations upon the spermatic tract fall into three groups: (1) operations upon the seminal vesicles, (2) operations upon the vasa deferentia, and (3) operations upon the spermatic cord.

The chief operative procedures carried out upon the seminal vesicles are *vesiculotomy* and *vesiculectomy*.

INDICATIONS FOR OPERATION UPON THE SEMINAL VESICLES

Indications for operation upon the seminal vesicles have been divided into 7 groups, according to the dominant symptom or manifestation present:

The inflammatory group. Those cases in which both the seminal vesicles and the prostate present acute suppurative lesions such as are commonly observed both in the abscess type and in tuberculosis of the spermatic tract.

The rheumatic group. Cases in which rheumatic and arthritic manifestations are present as the result of a focal infection in the seminal vesicles.

The pain group. Cases in which pain is the essential common factor. Here belong those cases in which there is perineal, suprapubic, or inguinal pain, with a certain amount of urinary and rectal symptoms, and, in addition, such symptoms in the spermatic tract as painful erection and coitus, bloody emissions, weak ejaculations, and, in some cases, impotence.

The neurasthenic group. Cases in which so-called sexual neurasthenia is present, with moderate physical signs of disease in the vesicles.

The psychotic group. Cases in which the graver forms of mental disorder are present, and in which examination reveals that the seminal vesicles are chronically inflamed and distended.

The neoplastic group. Cases in which (1) the malignant lesion is confined to one or both of the seminal vesicles and the invasion is not yet very extensive, and with no evidence of bony or general metastasis, and (2) those in which the malignancy of the prostate has involved the vesicles, but in which a perineal total prostato-ampullo-vesiculectomy can still be carried out.

The postoperative group. Cases in which the patient, after perineal or suprapubic operation of any type, but especially after vesiculotomy or prostatectomy, continues to suffer from urinary symptoms and sexual disorders requiring radical relief, and in which the infected seminal vesicles, distended and inflamed, are the direct cause of the patient's postoperative complaint.

In all these types of cases, surgical measures are required to bring about relief. In some of them, this can be accomplished by surgical drainage (vesiculotomy); in others, excision of the seminal vesicle is required (vesiculectomy), and, indeed, this is the operation of choice whenever possible.

VESICULOTOMY

Value of surgical drainage of the seminal vesicles. In view of the extremely irregular and complicated structure of the seminal vesicles, with their many crypts and recesses, large and small, it is evident that in severe cases of chronic infection there can be no effective drainage for such organs by any natural route, and that recourse must accordingly be had to surgical incision to release the pent-up masses of purulent secretion. It is true that where the seminal vesicle is a comparatively straight and simple tube, with but few diverticula, early spontaneous resolution may be possible, or drainage may be effected by massage of the organ; but the majority of vesicles are not of this type. In many of them, therefore, it is necessary to lay the substance of the vesicle wide open, and to incise the individual compartments, thus providing for artificial drainage on an adequate scale. (See Fig. 28.) Theoretically, this can be done through an abdominal incision, by dividing the rectovesical fold of the peritoneum; but practically, the safest and most advantageous approach is through the perineum. Several technics have been devised for the procedure.

Fuller's technic for vesiculotomy. The first vesiculotomy performed by Fuller was in the nature of an accidental procedure, his intent having been to do a vesiculectomy; this was thwarted, however, by the close adhesions he encountered and the extreme friability of the organ, in consequence of which he had to rest content with curetting and draining it. The complete cure that followed in 3 weeks led Fuller to systematize his procedure as follows:

The approach to the vesicles is by a very wide perineotomy of the superficial planes, in the form of a broad inverted U, followed, rather paradoxically, by a blind operation as regards the deeper tissues, which are not visualized but are recognized only by touch. The patient is prepared as for any other perineal operation, the aim of the latter being to minimize the risk of sepsis which might attend the introduction of a finger into the rectum during nearly the entire course of the operation. He is placed in the knee-chest position, on an inclined table, with head downward, two assistants maintaining him in this position during the entire operation.

The incision is made with the arms of the U at the sides of the anus and spreading outward at the top (back), and its horizontal base passing 3 cm. in front of the anus, thus uniting the tuberosities of the ischia by a slightly curved line. The vertical arms are prolonged backward as far as the base of the coccyx. This wide incision is of sufficient size to obviate any danger to the rectum, and permits blunt dissection of the tissues lying above the perineum until the prostate is reached, after which the vesicles are oriented by touch at the right and left of it. (Some operators prefer a V-incision or a crescent-shaped incision; after making this, the median tendon is divided, the ischial fossa opened on each side by blunt dissection, and the recto-urethral muscle divided.) In the original procedure, the surgeon introduces his left index finger into the anus, and places it against the anterior wall of the intestine; it thus becomes the buttress against which the various muscles are cut successively on the way to the vesicle: the superficial muscles of the perineum, the levatores ani, and the levatores of the deep perineal aponeurosis. The fascia is picked up and incised first over one vesicle, then the other, after which the vesicles are laid open and as many punctures or incisions made as may be required. Fuller introduced at this point, under control of the finger within the rectum, a grooved sound, which follows the posterior aspect of the vesicle over its entire length and protects the rectum behind it. With this sound serving as a guide, and the back of the knife gliding in its groove, the posterior wall of the vesicle is incised, proper care being taken not to injure the bladder. A finger is then introduced in order to enlarge the opening in the vesicle and to remove any collections of pus that may be found, after which a curette finishes the work of evacuation. Each vesicle is treated in turn, after which a cigaret drain is placed on each side and the wound closed, except for drainage through the horizontal breach.

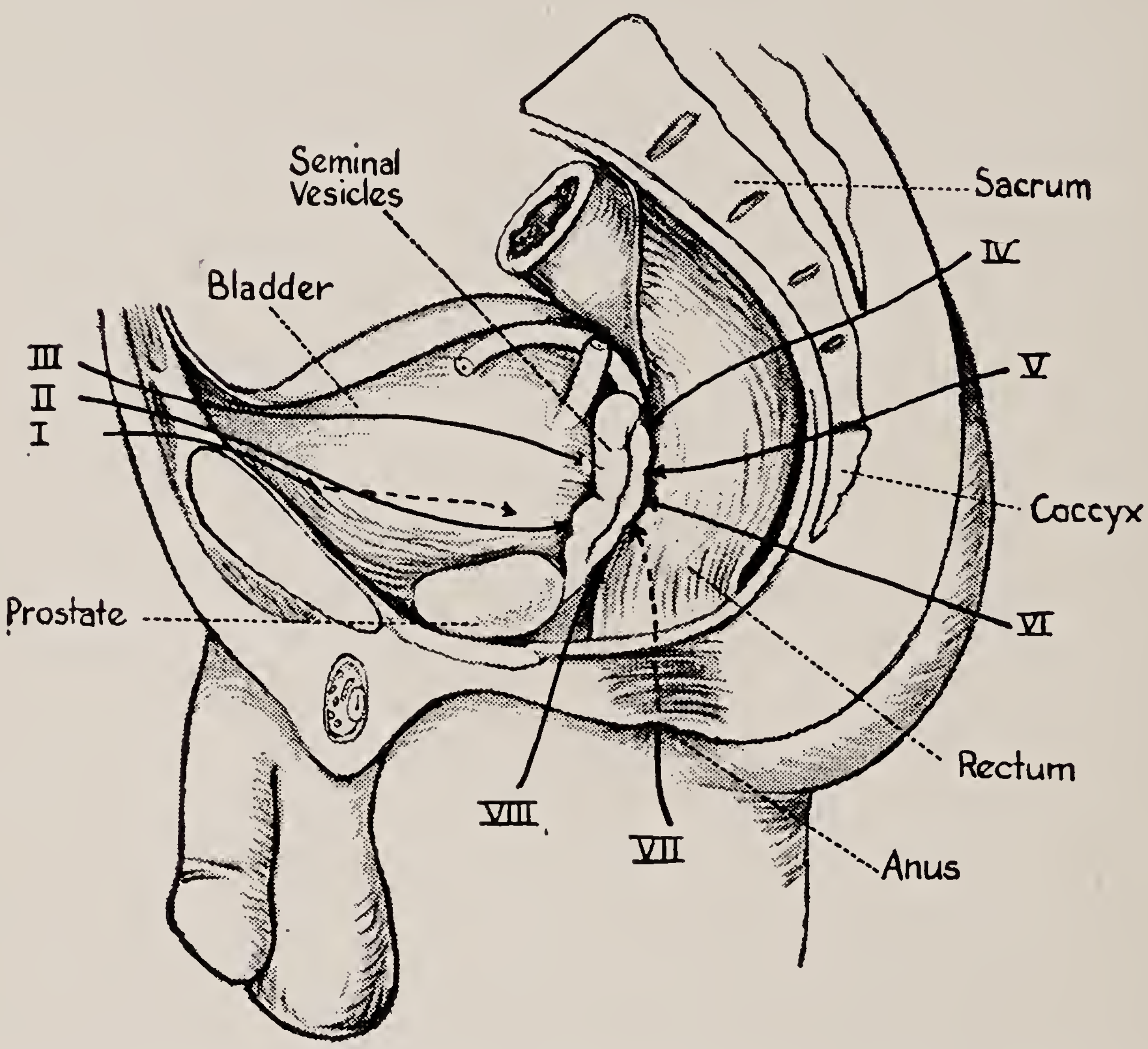


FIG. 28. The different methods of surgical approach to the seminal vesicles:

I. The transvesical.
II. The suprapubic.
III. The inguinal.
IV. The sacral or parasacral.
V. The coccygoperineal.
VI. The ischiorectal.
VII. The ano-coccygoperineal.
VIII. The perineal.

Since Fuller's time, the technic has been improved to permit the operator to work under vision. After the dissection between the rectum, prostate, and base of the bladder has been carried out, a deep flexible ribbon tractor, with a piece of gauze folded between it and the rectum, is placed in the wound, and two traction sutures of heavy silk are threaded through the tissue at the point where the bases of the prostate and bladder come together. Traction in a forward and downward direction upon these threads will bring the vesicles into better view for the final stages of the operation.

Cunningham uses a technic in which, after protecting the rectum with a piece of gauze in the bottom of the wound, he inserts a flat self-retaining retractor 1½ to 2 inches wide, having an abrupt curve and long enough to reach the bottom of the wound. Then, by means of a special double tenaculum, the prostate is lifted enough to expose the base of the bladder, whereupon the vesicles become visible beneath the glistening aponeurosis of Denonvilliers. The latter is divided along the superior border of the prostate and stripped back, as a whole, to expose the two vesicles at the same time.

A technic was described by Squier in which, after exposure of the prostate by the perineal method, two stout silk sutures are introduced through the prostate and bladder wall at the junction of the prostate and the base of the bladder. They are placed as far laterally as possible. Traction is then made upon these sutures in a downward direction, resulting in the forward rotation of the base of the bladder through an arc of about 60°, thus exposing the fascia of Denonvilliers covering the vesicle.

Vesiculotomy with prostatotomy (multiple incision method). In this procedure, used by Smith and Morrissey, both the prostate and the vesicles are liberally incised under full vision and all diverticula opened to provide adequate drainage for all recesses and crypts. This method is suitable for use only where the vesicles cannot be removed without destruction or injury to surrounding parts, and where there are no gross changes in the vas. Concomitant incision of the prostate is one of the most important steps of the procedure. The technic of this combined method of drainage begins with the usual perineal incision and dissection of tissues as if a perineal prostatectomy were to be carried out. After opening the two layers of Denonvilliers' fascia, the vesicles and prostate appear in full view. Incision is first made in the vesicle at the point where it joins the ampulla, after which multiple incisions are placed along the axis of the organ. (See Fig. 29.) If both vesicles are involved in the chronic inflammation, the same procedure is performed upon the other organ. The interior of each vesicle is then swabbed out with carbolic acid and neutralized by alcohol. Sections of the wall are taken for examination, and specimens of the secretion for culture and smear. The prostate is also incised liberally and specimens similarly taken for examination, after which drainage tubes are inserted at the various sites of incision in both

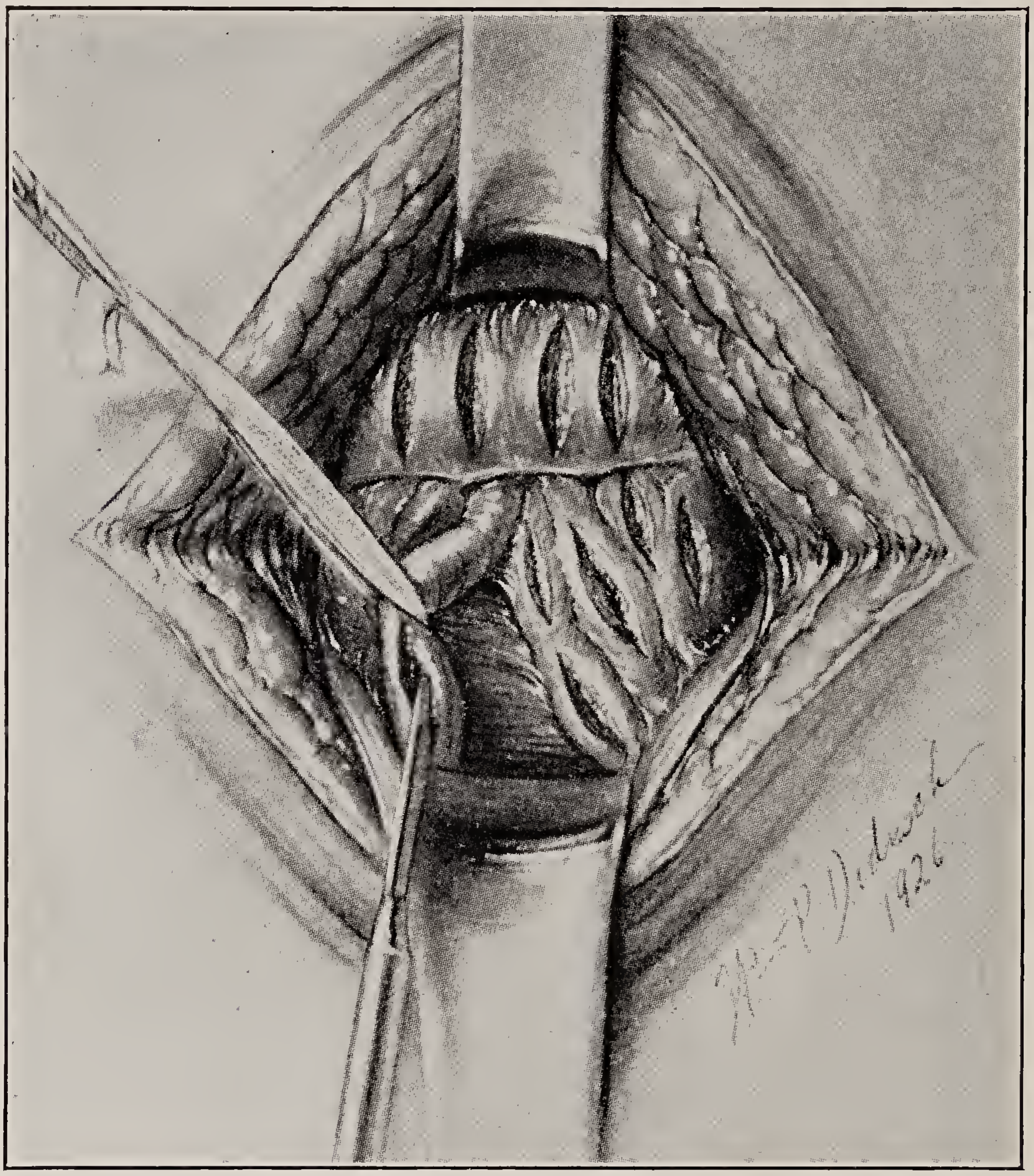


Fig. 29. Drawing showing the modern method of multiple incision of the anatomically exposed prostate, seminal vesicles, ampullæ, and vasa deferentia, reached by the perineal route. (From J. H. Morrissey, Surgery, Gynecology and Obstetrics, p. 347, 1928.)

the prostate and the vesicles. The capsule is then sutured in two places, and the wound closed as in prostatectomy.

VESICULECTOMY

Many different methods and technics for the removal of the seminal vesicles have been described. They fall primarily into 3 groups, according to the mode of approach. (See Fig. 28.)

(1) Inferior approach
(2) Anterior approach
(3) Posterior approach

(1) The inferior approach includes 2 different procedures:
  (*a*) The perineal operation
  (*b*) The ischiorectal operation
(2) The anterior approach embraces 3 separate procedures:
  (*a*) The suprapubic method
  (*b*) The transvesical method
  (*c*) The inguinal method
(3) The posterior approach comprises 4 different procedures:
  (*a*) The sacral method
  (*b*) The parasacral method
  (*c*) The coccygoperineal method
  (*d*) The ano-coccygoperineal method

Indications. Among the many indications for vesiculectomy may be mentioned: tuberculosis of the spermatic tract, tumors of the vesicles, cyst formation, abscesses, calculi, and a very important group of cases consisting of chronic inflammation, gonorrheal and nongonorrheal, in which the vesicles play the rôle of foci of infection, menacing the health of the body in general.

The perineal operation. This method of extirpation of the vesicles was the first to be employed (Ullmann, 1889) and it has received the preponderance of attention in the literature since the time of the early writers on the subject. The feasibility of this route in exposing the prostate and the seminal vesicles has been pointed out by Zuckerkandl, Ullmann, Roux, Weir, von Dittel, Lloyd, Albarran, Proust, Guelliot, Baudet and Kendirdjy, and other early surgeons. Modifications of the original method have been introduced by Young, Squier, Caulk, Cunningham, Geraghty, Lowsley, Gutierrez, Smith and Morrissey, and the method, with its modifications, remains the operation of choice. It is extraurethral, extravesical and extraperitoneal; consequently the common sequels mentioned by many writers, such as perineal or rectal fistula, epididymitis, and urinary incontinence, are not encountered.

Anesthesia. Operation upon the spermatic tract may be performed under any type of anesthesia. In most instances general anesthesia under nitrous oxide and ether has been employed to obtain narcosis, although local anesthesia for any type of operation on this tract is also suitable. The epidural method, or sacral or parasacral block infiltration may likewise be used. But it appears

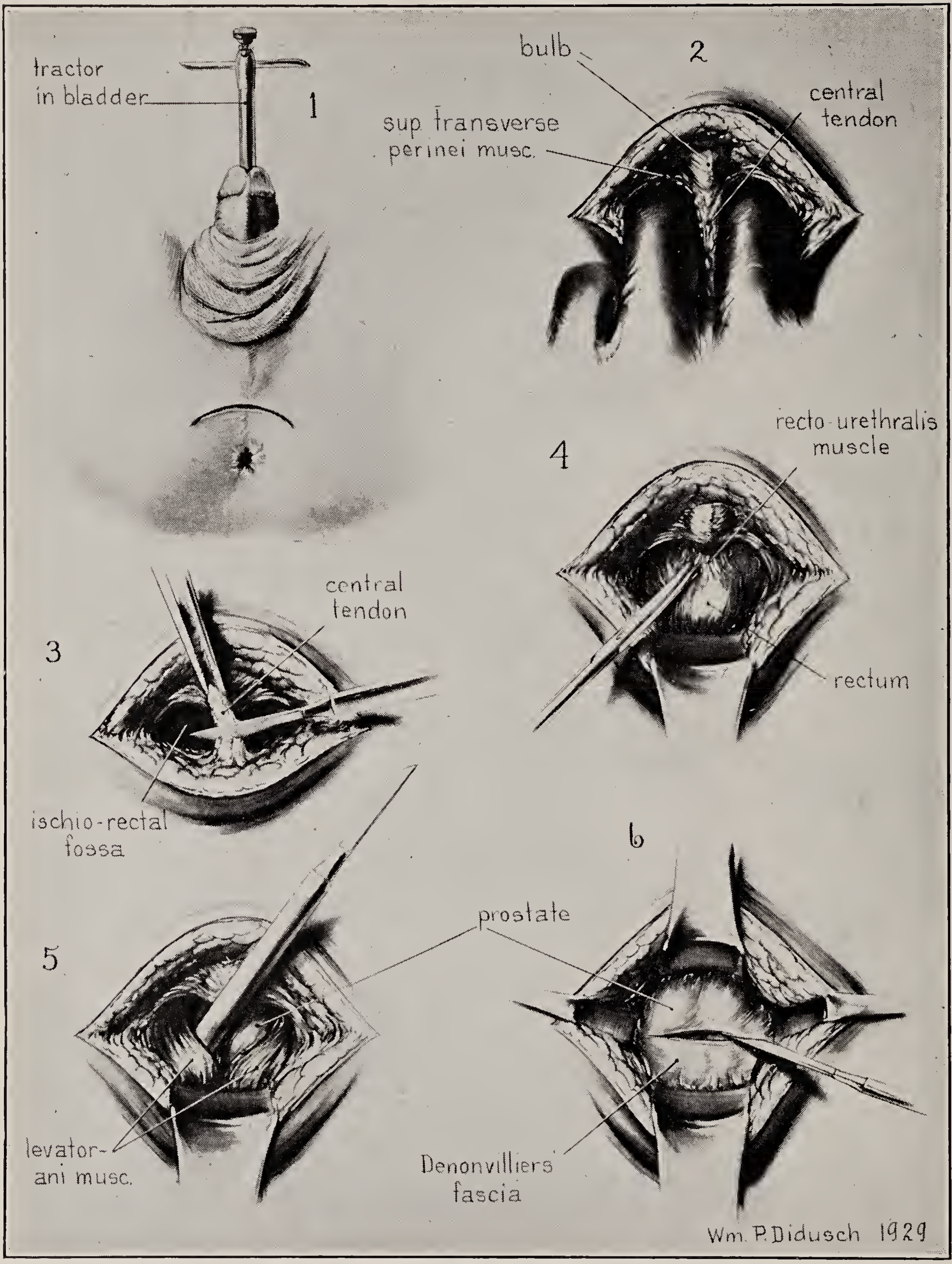


FIG. 30. See caption on page 746 (447).

FIG. 30. Operative technic of the perineal method. 1. Patient in exaggerated lithotomy position as for perineal prostatectomy; seminal vesicle urethral tractor in position. A semilunar perineal incision is made. 2. Index finger in ischial fossa, gaining line of cleavage of the superficial perineal muscles by blunt dissection. 3. Exposing bulb of urethra and cutting central tendon of the two ischiorectal fossæ. 4. With bulb tractor in position, the recto-urethralis muscle is cut with scissors to separate the rectal attachments from the apex of the prostate. 5. Method of separating by blunt dissection the levator ani muscles and the remaining fibers of the recto-urethralis muscle from its attachments to surface of the prostate. 6. Exposure of glistening fascia of Denonvilliers covering prostate gland; superficial transverse incision, cutting first layer of Denonvilliers' aponeurosis, with bulb and deep perineal tractor in position; use of two lateral tractors for better exposure.

that the most simple of all methods is spinal anesthesia, using as a medium novocain, nupercain, or spinocain. However, the type of anesthesia chosen should be the one most suitable for the individual case.

Technic. The following is the technic of the perineal method as used by Gutierrez in over 150 seminal vesiculectomies.

With the patient in the exaggerated lithotomy position, as for perineal prostatectomy, and with the urethral seminal vesicle tractor in position, a semilunar incision is made at the raphe of the bulb just between the scrotum and the rectum, running from one ischial tuberosity to the other. (See Fig. 30.) The incision is carried deeper into each side of the central tendon, and then, by blunt dissection with the handle of the knife and the index fingers, the central tendon is divided and the bulb properly retracted. At this time, if any bleeding is encountered from branches of the bulbar artery, these are clamped and tied. To prevent unnecessary bleeding special care should be taken not to cut into the bulb.

With perfect traction on the bulb and perineal flap by the bifid perineal retractor, the recto-urethralis muscle is carefully divided and gradually separated from the rectal attachments and from the apex of the prostate. Then, by means of the index finger inserted for the purpose, the prostate is gradually liberated and separated from the remaining fibers of the recto-urethralis muscle. The levator ani muscles, constituting the floor of the pelvis, are then carefully retracted. A few muscular fibers still remain, and these are stripped from the surface of the prostate by gauze dissection. The prostate is exposed, covered by the glistening fascia of Denonvilliers. A superficial transverse incision is made at about the middle of the prostate. The first layer of Denonvilliers' aponeuro-

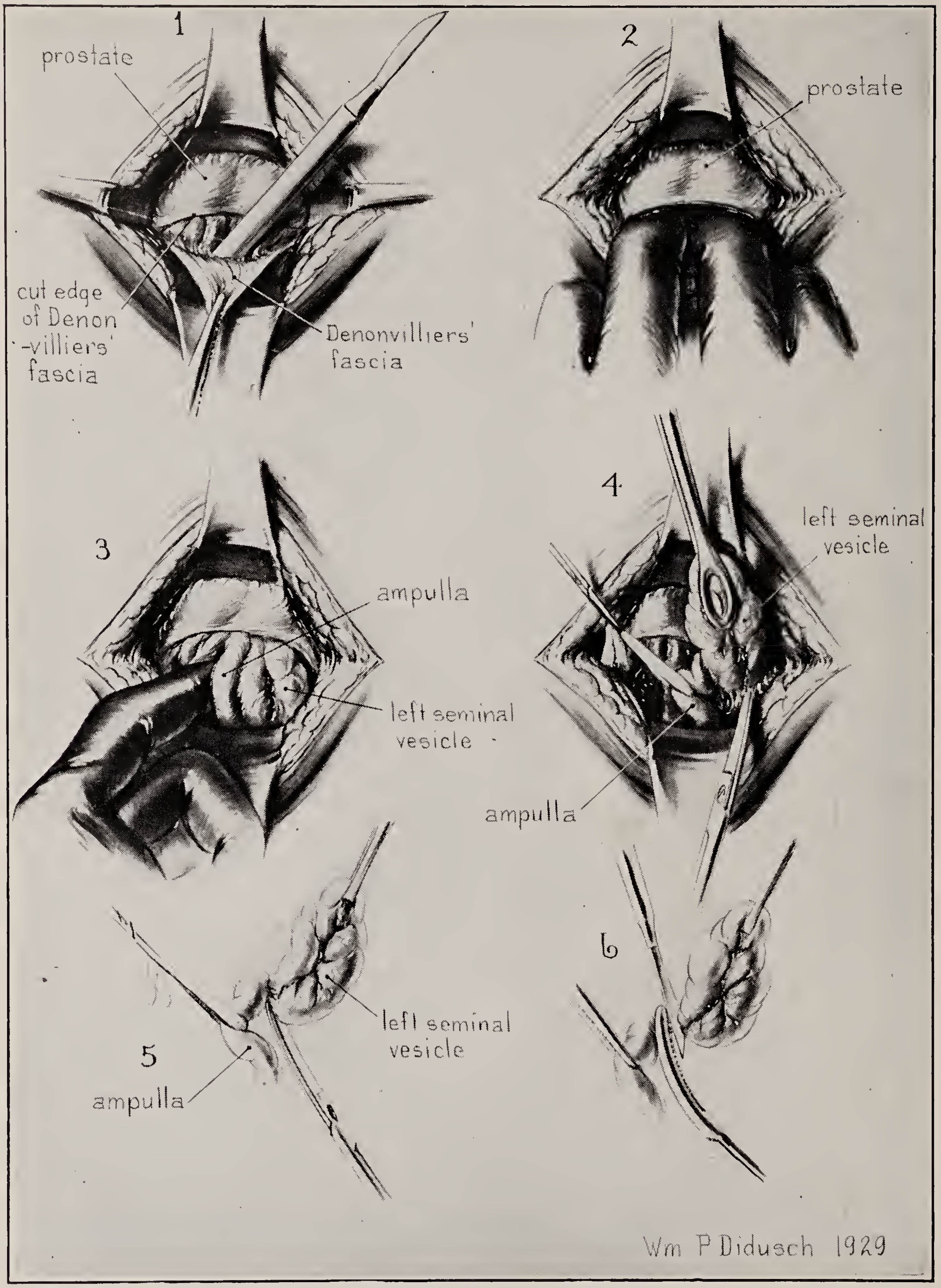


FIG. 31. See caption on page 746 (449).

FIG. 31. Operative technic of the perineal method: 1. Dissecting second layer of Denonvilliers' aponeurosis from the posterior face of the prostate with the blade of the knife; recognition of these two layers of prostatic fascia is essential. 2. Index fingers separating deeply, by blunt dissection, Denonvilliers' aponeurosis from the base of the prostate, and stripping the layers back from the base of the bladder to free vesicles from net of fascia. 3. Enucleation of the seminal vesicles with the finger tips, after careful blunt dissection of tip of vesicle. 4. Dissection of seminal vesicles from the fascial plane of adhesions, and separation from ampullæ. 5. Method of separating and dissecting the seminal vesicles entirely free from the ampullæ. 6. Method of clamping and excising the seminal vesicles from the ampullæ.

sis is gradually dissected back by the blade of the knife and, after being well separated, is retracted with the deep perineal retractor. A second incision is then made and the second layer of Denonvilliers' aponeurosis dissected, as illustrated in Figure 30. It is essential that the two layers of Denonvilliers' aponeurosis be carefully separated and the fascia stripped well behind the base of the prostate and the base of the bladder, because otherwise the exposure is most difficult and unsatisfactory.

The enucleation of the vesicle is begun with the tip of the index finger, an attempt being made to reach the tip of the vesicle laterally and externally to the vas deferens. Exposing the vesicle is difficult because of the many adhesions encountered, particularly in those cases of long-standing inflammation in which a process of perivesiculitis is present.

By careful dissection, with the help of good retraction and scissors and forceps, the left vesicle is easily exposed and separated from the ampulla, as illustrated in Figure 31. After it has been clamped, the right vesicle is exposed in the same manner. When both organs are chronically diseased, they are both removed. When the vesicles are clamped close to the ducts that unite with the ampullæ, they are cut off and the stumps touched with phenol (carbolic acid) and alcohol, followed by a single catgut suture, as illustrated in Figures 31 and 32. The ampullæ are carefully examined to assure patency, and then the operation is finished.

It is of particular importance, in closing the wound, to make 3 or 4 sutures near the edges of Denonvilliers' aponeuroses, as in Figure 32, in order to reconstruct all the anatomical planes and give perfect support to the structures of the deep pelvis, particularly the new retrovesical space with the prostate, rectum, and peritoneum. Finally, two cigaret drains should be inserted, one inside the prostatovesical space and the other in the retrovesical space behind the reconstructed prostato-fascial layers of Denonvilliers' aponeuroses. The levator ani muscles are drawn together with two separate deep sutures of chromic catgut, thus closing the floor of the pelvis and leaving the cigaret drains in place, as in Figure 32. The wound is closed by bringing the two edges of the skin together by interrupted silkworm-gut stitches, and a dressing is applied. As a rule, there is no bleeding or any other complication and the wound heals firmly in about two weeks.

The long urethral seminal vesicle tractor, described by Young, should be placed in position at the beginning of the operation, as illustrated in Figure 30, because it is of great assistance in bringing the prostate to view and in maintaining the proper relationship during the different stages of the operation. The bladder should be filled before the operation with a mild antiseptic solution, such as boric acid or distilled water, for the purpose of having a more resistant plane in the anatomical dissection for a better exposure. The establishment of the plane of cleavage at the time of the enucleation of the vesicles is greatly facilitated in this manner and the separation of the vesicles from the ampullæ is more easily accomplished. Hot compresses may be used, when there is oozing or bleeding, to save time and to keep the operative field clean. No actual hemorrhage or shock is encountered.

Special care should be taken to keep away from the rectum when cutting the recto-urethralis muscle, to avoid the formation of rectal fistula. In certain cases it is advisable to be guided by the left index finger in the rectum, to protect the viscus from injury.

The membranous urethra is exposed during the operation and the triangular ligament at the apex of the prostate is also seen, but as the urethra is not opened and neither sphincter is cut, incontinence of urine has never been observed.

On the whole, this operation seems to upset the patients less than many other surgical procedures.

Young's procedure. For the surgical treatment of tuberculosis of the seminal vesicles, Young conceived the radical operation of excision of the entire spermatic tract. Since a study of statistics seems to prove conclusively that in the great majority of cases of tuberculosis of the tract the primary involvement is in the seminal vesicles (or prostate), from which the epididymes or testes are subsequently involved, it is the duty of the surgeon to attack the most dangerous focus of involvement, and to do a radical operation upon the entire tract.

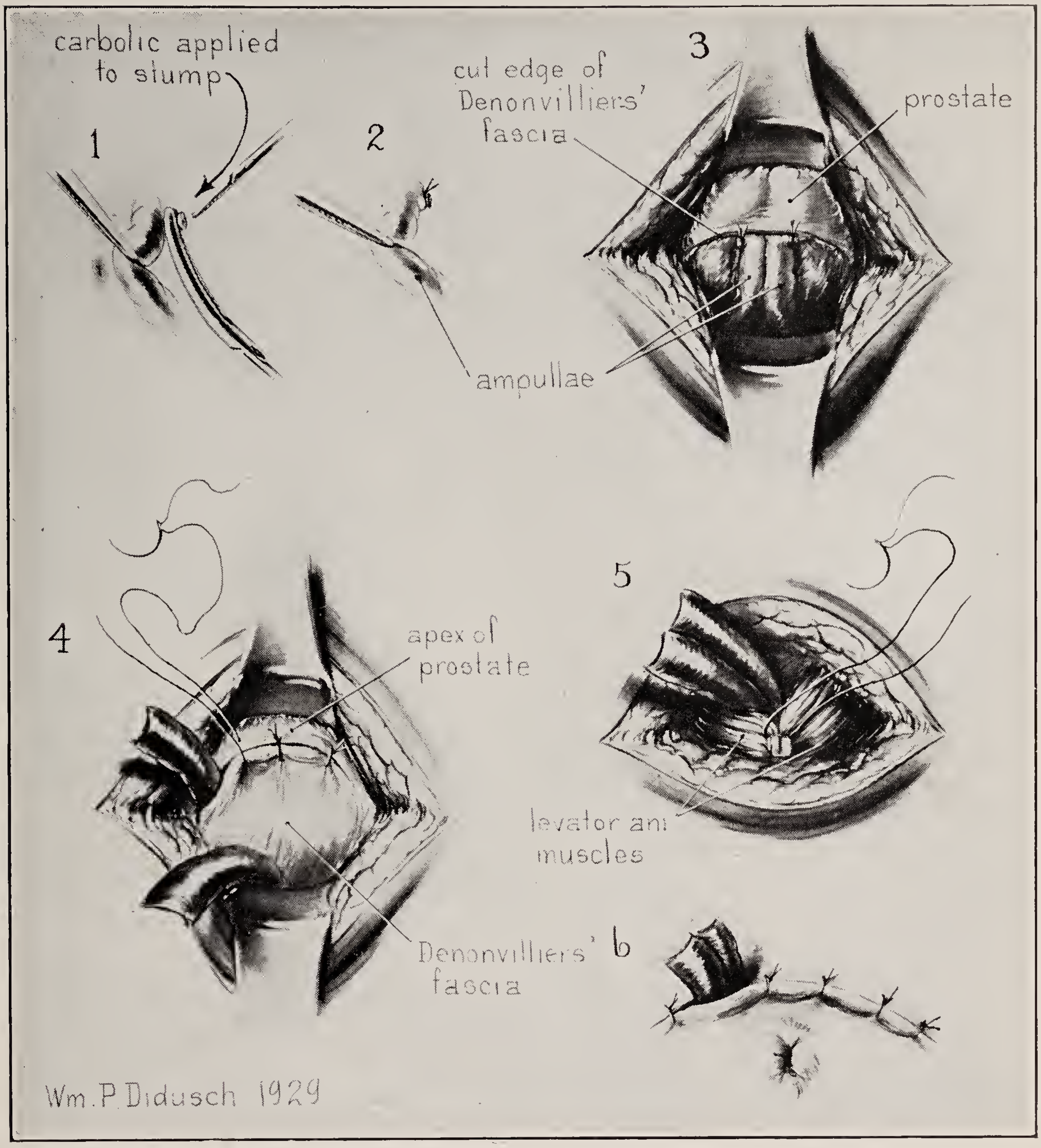


Fig. 32. Operative technic of the perineal method: 1. Method of applying phenol, following alcohol, to stump of ampulla. 2. Ligature after vesicle has been excised, with normal integrity of remaining ampullæ. 3. Bulb and perineal tractor in position, showing complete and most satisfactory view of the operating field and the patency of the two ampullæ of the vasa deferentia, remaining after seminal vesicles have been removed. 4. Method of suturing fascia of Denonvilliers' aponeurosis to secure perfect healing; reconstruction of this anatomical structure is of paramount importance. A small cigaret drain is placed at the base of the prostate, and another behind the reconstructed fascial plane deep in the perineum. 5. Reconstruction of the perineum, bringing the two levator ani muscles together by two deep sutures; cigaret drains brought to one side. 6. Closure of wound with interrupted silkworm-gut, leaving cigaret drains in place.

Young uses the perineal operation, as described above, but at the moment of opening the second (deep) layer of Denonvilliers' aponeurosis he prefers a Y-incision as more advantageous for cases in which both vesicles, the ampullæ, and the lateral lobes of the prostate are involved, since it gives an excellent exposure of all these structures. When this aponeurosis or fascia is elevated on both sides all are readily visible, while the central portion of the prostate, in which the ejaculatory ducts lie, is left intact and covered by fascia, which aids in protecting them. In this way it is possible to determine exactly how much should be removed,

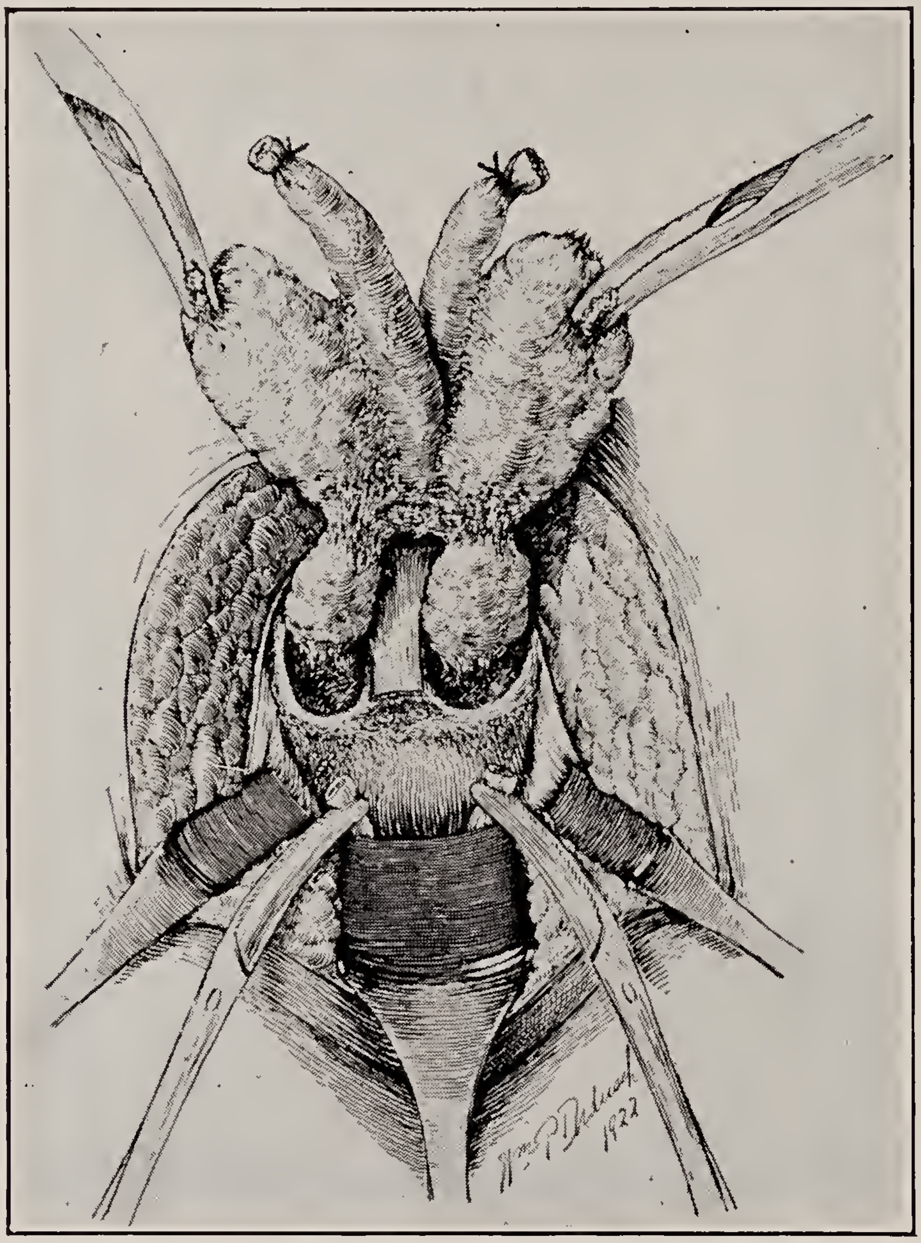


Fig. 33. Young's radical procedure for the removal of the spermatic tract in tuberculosis. The seminal vesicles and ampullæ have been freed and are held up by clamps, the ampullæ having previously been ligated and cut off from the vasa deferentia, in each of which a clamp is left *in situ* for further maneuvers. The lateral lobes of the prostate are being enucleated by blunt dissection, leaving the prostatic urethra with the ejaculatory ducts intact. (Courtesy of Dr. H. H. Young. From Young's *Practice of Urology*, Vol. II, p. 524, W. B. Saunders Co., 1926.)

whether the disease is unilateral or bilateral, and whether one or both lobes of the prostate should be excised. Another advantage is that the main blood supply, which lies externally, is thus drawn outward with the fascia, and hemorrhage is avoided, making it possible to see the field well and to carry out a delicate and accurate blunt dissection without injury to the bladder, to which the ampullæ and vesicles are often adherent.

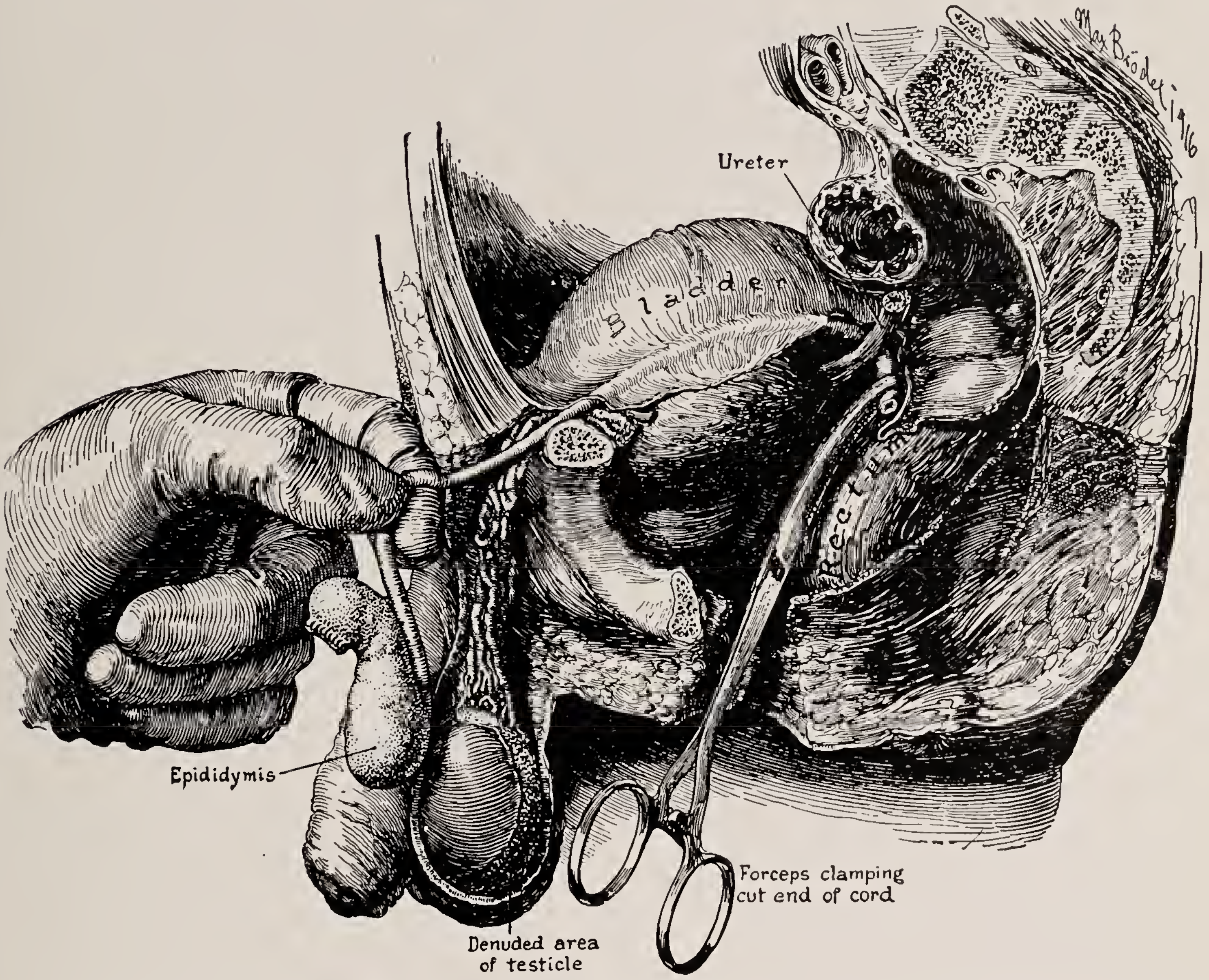


FIG. 34. Second stage of Young's radical procedure for the removal of the spermatic tract in tuberculosis. The epididymis has been exposed and severed from the testis; the scrotal portion of the vas is isolated and dissected free from the other elements of the cord; it is then removed through the groin by pulling alternately on the clamp that has been placed around the vas at its vesicular end and on the portion of the vas emerging from the wound in the groin. When the vas is thought to be free the clamp is removed and the vas drawn out through the groin. (Courtesy of Dr. H. H. Young. From Young's *Practice of Urology*, Vol. II, p. 528. W. B. Saunders Co., 1926.)

The vas deferens should be freed well up toward the point where it winds around the ureter, then deeply clamped and divided, the upper clamp being left attached to assist in removal of the upper portion of the vas deferens, in case epididymectomy or castration is contemplated. Working from above downward, the vesicle and ampulla are freed until the juncture with the upper portion of the prostate is reached. If it then seems desirable to remove a portion of the prostate, an incision is made parallel to and at a distance of 5 mm. from the urethra (and dividing the ejaculatory duct), but leaving sufficient tissue to avoid a urinary fistula. After this the prostatic tissue is easily removed by enucleation from within its capsule, and the fascia, ampulla, seminal vesicle, and lateral lobe of the prostate are thus all removed in one piece. If the disease is bilateral, the same procedure is carried out on the opposite side, not separating the two sides from one another but removing the entire upper part of the tract in one piece. (See Fig. 33.) The wound is then partly closed, leaving two iodoform gauze drains, the long clamps being left attached to the upper ends of the vasa deferentia for traction later.

The patient is then placed on his back, with legs separated, and epididymectomy or castration carried out, according to the extent of the lesion. The incision is usually made along the cord, just below the external ring, and after division of the dartos the testis is delivered, the tunica vaginalis opened, separation of the vas and epididymis from the veins and testis carried out, and, finally, division at the upper end of the epididymis made with a cautery. After suturing the tunica behind the testis so as to avoid hydrocele formation, and after careful hemostasis, the testes and veins are dropped back into the scrotum, and the vas deferens, which has been exposed up to the external ring, is then freed from adhesions in its canal by a to-and-fro traction produced by an assistant pulling upon the clamp (which has been left upon the lower end of the vas), alternating with traction by the operator on the vas deferens in the groin, after which it is easily drawn out in its entirety through the groin. (See Fig. 34.) In this way is accomplished complete and radical removal of the entire seminal tract, with the exception of a few millimeters, the terminal portion of the ejaculatory duct, and we have also a conservative prostatectomy, leaving the urethra and bladder intact. The whole procedure is carried out with ease, under visual control. Young regards this procedure as the only one justifiable in tuberculosis of the seminal vesicles and epididymes. The results reported have, on the whole, been encouraging, although advanced genital tuberculosis is a very grave condition and is commonly accompanied by tuberculosis elsewhere, particularly in the upper urinary tract.

The ischiorectal (Voelcker's) method. This method, designed to avoid the difficulties of recto-urethral stripping, consists of 4 main points:

(1) A lateral incision is made, or one on the left side, if it is desired to have the same incision give access to both vesicles. A curved incision is made, beginning at the midline, 2 fingerbreadths in front of the anus, curving inward to pass at mid-distance between the anus and the ischium, and terminating again upon the midline toward the base of the coccyx or higher up as far as the fourth sacral vertebra.

(2) The ischiorectal fossa is traversed, the levator ani discovered and widely exposed; it is then incised longitudinally to permit entrance into the superior pelvirectal space. The bottom of the wound is then constituted by the deep perineal aponeurosis which conceals the pelvic organs; it must be incised parallel to the long axis of the rectum, upon the anterior margin of the latter. This leads the way into the interprostatorectal space.

(3) This space is split with the finger, the rectum pushed backward and the prostatovesicular region exposed, lying spread out in the bottom of the wound. After incision of the prostatoperineal aponeurosis, the vesicles come into view.

(4) It only remains now to isolate the vesicles, remembering that their vascular pedicle runs along their external margin. This should, therefore, be the last point isolated, in order not to be handicapped by bleeding.

In difficult cases, Voelcker himself advises that the exposure be improved by disarticulating or resecting the coccyx, which brings us to Fiolle's operation.

It is also possible to combine this method with the perineal procedure by prolonging the incision by a hemi-circumference which, concave on its posterior aspect, surrounds the anus and even passes behind it to the ischium of the opposite side.

The method, although none too easy of execution, is applicable in the treatment of unilateral genital tuberculosis since it is the only one that permits the total extirpation of a solitary focus at one sitting.

The suprapubic method (Young, 1900) removes the two vesicles by a single median incision, and is a veritable subumbilical and subserous laparotomy. The incision arrives at the lesions by passing around the lateral walls and then the posterior wall of the bladder, which are progressively stripped of their peritoneum; and, although the bladder is systematically opened, the vesiculectomy cannot be called transvesical. Young sums up his technic as follows:

A median laparotomy incision is made from umbilicus to pubes, scrupulously sparing the peritoneum. A transverse T-shaped incision is made upon the preceding line, immediately below the umbilicus. This may involve the recti muscles more or less deeply, or even pass through them altogether.

The anterior aspect of the bladder is opened, the organ explored, and catheters inserted in the ureters to avoid wounding them at a later time. The bladder wall is seized and held taut while the parietal peritoneum is separated from its posterior surface as far as the bottom of Douglas' cul-de-sac. This is quite easy, although anatomists describe close adhesions between this surface and its serous covering.

The vesicles are exposed and isolated successively in their normal position behind the bladder wall, and the vasa deferentia also, borne along by the peritoneum, to which they remain adherent; both vesicles and vasa are widely resected and, if necessary, the diseased base of the prostate as well. Excision of portions of the diseased vesicles follows in cases where tuberculous lesions have been transmitted to the bladder, after which the wound is closed and drained. Extirpation of the vaso-testicular lesions is then done by two independent inguinoscrotal incisions.

This laborious operation, which takes 2½ hours to perform, in some cases involves serious destruction of walls and constitutes for patients in poor condition a grave traumatism almost beyond their endurance. Legueu and other European surgeons have also tried this suprapubic or inguinal method, but they regard it with little enthusiasm, owing to the difficulties of the surgical exposure and the impossibility of providing proper drainage, the procedure being followed in some instances by suprapubic fistulæ.

The transvesical method. This technic has been employed by Marion, Pauchet, Thomson-Walker, Cathelin, and certain other surgeons. It is used at times for prostatic tumors, and all are agreed as to the severity of the procedure. Pauchet, however, had only one death in 5 cases. The danger lies in hemorrhage, occurring either immediately after operation or later, and also in the risk of pelvic infection.

Thomson-Walker's method. Thomson-Walker proposed that in simple cases of vesiculitis a methodical transtrigonal vesiculectomy be performed. (See Fig. 35.) He does a wide cystostomy and then places within the bladder a vesical retractor, giving a wide exposure of the trigone. The bladder wall is incised at the level of the trigone in the shape of an inverted letter T, the vertical branch of which is in the axis of the trigone, while the horizontal branch, 2 cm. long, passes immediately behind the urethral orifice. The two triangular flaps thus created are lifted up, disclosing the seminal vesicles. The latter are seized with forceps and fixed, then gently isolated with the point of curved scissors. They are then resected, along with the portion of prostate adherent to them. The wound is packed or a suture of the parietal flaps is done. Thomson-Walker has done this operation twice, and is much pleased with it, claiming that it is the most direct approach to the vesicle, that it does not expose the rectal wall to trauma, and that it respects the external sphincter. Others, however, among them Chiaudano, point out the danger of infection passing from the vesicular bed into the pelvic spaces, especially since this bed is at the lowest gravitational point and hence not favorable for drainage.

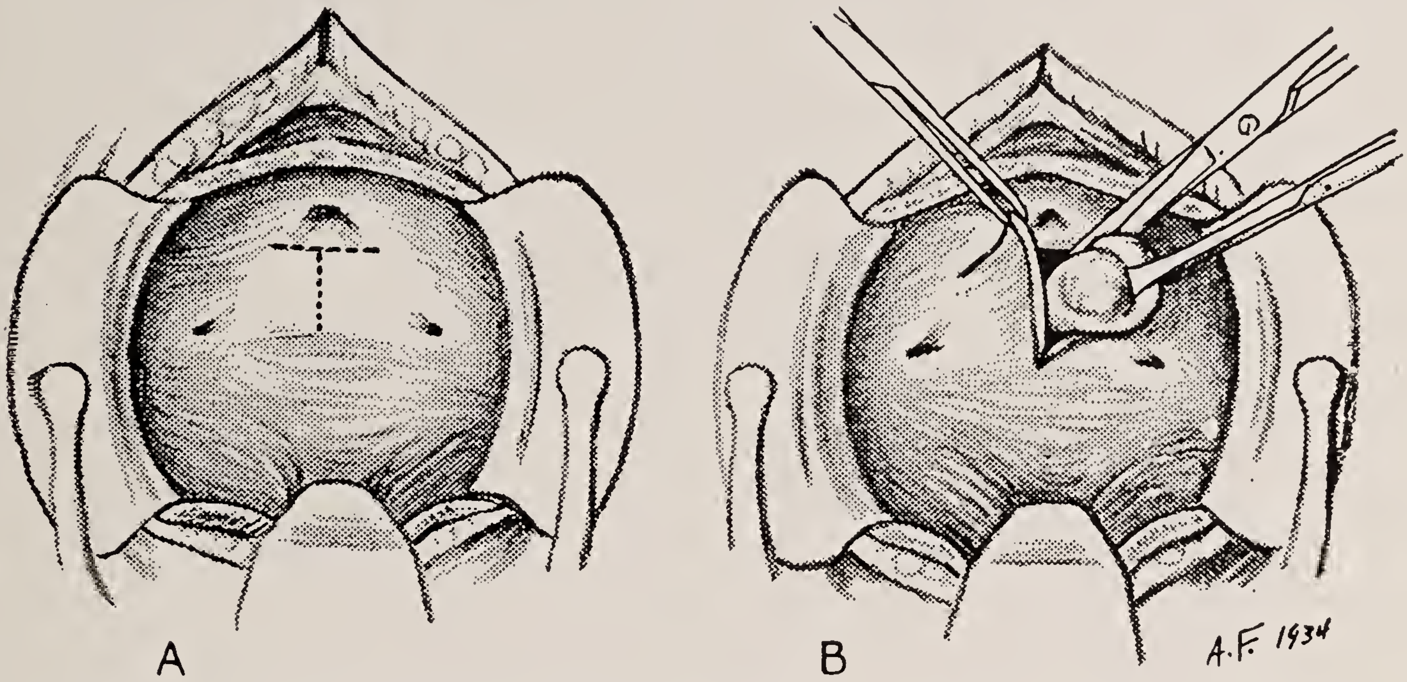


FIG. 35. The transvesical method of approach to the seminal vesicles.

A. With the bladder open, as in an ordinary cystostomy, an inverted T-shaped incision is made in the area of the trigone, in order to expose the seminal vesicles in the retrovesical space.

B. The left seminal vesicle is exposed, dissected free, clamped and incised, for the purpose of accomplishing vesiculectomy or vesiculotomy, as may be indicated. This method, described by Thomson-Walker, has been employed with certain modifications by Marion, Pauchet, and others in cases of carcinoma of the prostate and seminal vesicles.

Transvesical prostatovesiculectomy. In applying the transvesical method to malignant conditions of the prostate and seminal vesicles, Marion and also Pauchet incise the bladder mucosa upon the circumference of the prostatic protrusion. The latter is then grasped with a tenaculum and, after methodical liberation of its anterior and lateral aspects as far as the membranous urethra, seized and lifted up. The posterior aspect of the prostate, together with both the seminal vesicles and their ampullæ, is freed, first from below upward, then from above downward, and the entire mass isolated *en bloc*, until it is held only by the vasa and a tiny vascular pedicle. These are tied and sectioned, after which hemostasis and tampons are required for the bladder wall.

Combined cysto-prostato-vesiculectomy for cancer. In certain cases of infiltrating carcinoma of the bladder, involving the prostate and seminal vesicles, the operative procedure should be the combined method of total removal of all these organs. The success of this formidable operation depends upon the preliminary preparation of the patient by the derivation of the urine either by bilateral nephrostomy, ureterostomy, or transplantation of the ureters into the bowel; and also upon securing perfect hemostasis and a good drainage of the cavity remaining after the operation has been complated. This operation has been performed since the time of Bardenheuer, Kuster and Pawlick (1887–1891). The original technic has been modified by Albarran, Beer, Federoff, Marion and others. Most of these surgeons make use of a combined abdominoperineal method in two stages. In the first stage the prostate and seminal vesicles are exposed and liberated through the perineum and the membranous urethra is cut at the apex of the prostate, leaving in place a good-sized rubber tube drainage, which will also serve to guide the surgeon and protect the rectum from injury. The second stage of the operation is then accomplished by the suprapubic method of extraperitoneal exposure of the whole bladder, together with the prostate, seminal vesicles, ampullæ and the upper part of the vasa deferentia, as well as the lower portion of both ureters, which have been previously sectioned. All these cancerous organs are then removed *en bloc*, thus accomplishing a total combined cysto-prostato-vesiculo-ampullo-vasectomy.

The inguinal method (vasovesiculectomy). The first to use this procedure was Villeneuve, in 1891. The technic, which included the forcible evulsion of the vas from the groin, was very imperfect and so much of the work had to be done blindly by the finger, making traction upon a vas already weakened by disease and hence almost sure to rupture, that the method, as first used, has been called by Chauvin "*une opération détestable.*" In 1901, Baudet and Duval, convinced of the possibility of increasing the usefulness of this means of approach, made certain changes in the technic, which resulted in a method which they described as follows: With the patient in the Trendelenburg position, a skin incision is made from

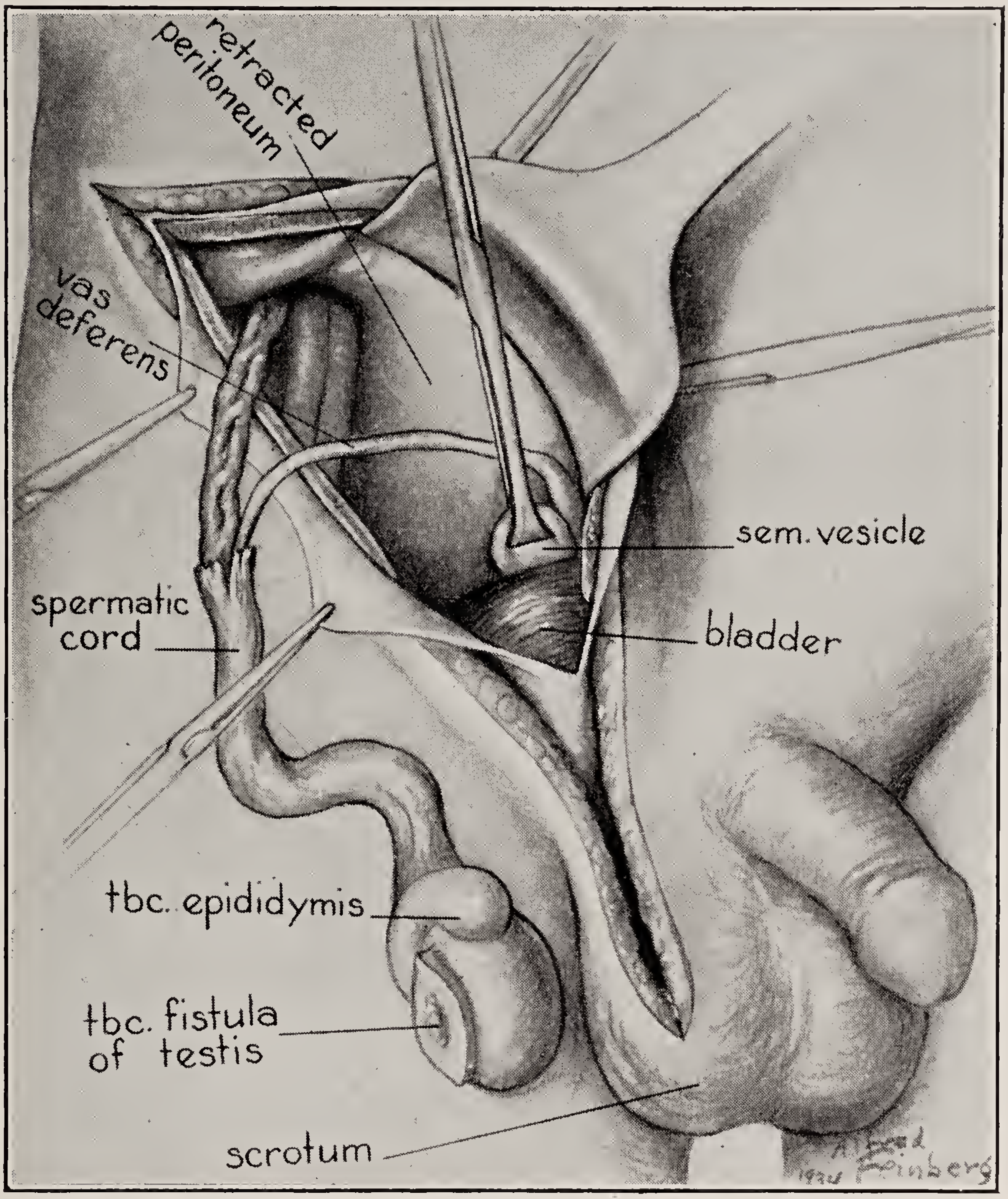


FIG. 36. Inguino-abdominal radical method of Villeneuve for total unilateral removal of the spermatic tract, including epididymis and testis, for tuberculosis. In this method, the testis may be saved when not tuberculous, removing only the tuberculous epididymis, vas, ampulla and seminal vesicle (epididymo-vaso-ampullo-vesiculectomy). This type of procedure has been used and modified by Baudet and Duval, Legueu, Villard, and others.

the middle of the frontal aspect of the scrotum on the affected side up to the inguinal ring, following the crural arch in a line parallel to and one fingerbreadth above it, as far as the anteroposterior spine, over which it curves backward. The epididymis and testis are removed and the cord freed up to the inguinal canal. (See Fig. 36.) The latter is opened for its length by section of the aponeurosis and muscles, as if for ligation of the external iliac. The transversalis fascia is opened and the epigastric artery tied if it gets in the way, as it nearly always does. The peritoneum is stripped off, keeping close to the serosa; by maintaining this close contact, the operator does not lose his landmarks in the maze of branches of the hypogastric along with the ureter; but he must bear in mind the possibility of wounding the bladder vessels or the ureter. Within the pelvis the work grows difficult; the exposure is poor, the wound deep and narrow. Under light reflected from brightly nickeled retractors, the intestine is held out of the way, and the vas, which has by this time been nearly freed, is now completely liberated, and its course followed down to the vesicle. The latter is exposed by incision of its capsule either transversely over its fundus or longitudinally on its external border; the vesicle and vas are sectioned close to the prostate, after which the wound is closed with drainage.

Legueu's modification. Legueu makes his skin incision in the opposite direction, beginning over the external border of the rectus muscle. He separates the iliopelvic peritoneum, locates and removes the vas and vesicle, and then treats the scrotal lesions by an independent incision, thus reversing the order of procedure from that of its originators.

Villard's modification. Villard uses a parietal incision, starting from the upper part of the scrotum; he follows the inguinal tract to its deep orifice; then, like Legueu, carries the incision upward again along the external border of the rectus, to within two fingerbreadths of the umbilicus, after which he employs the technic of Baudet and Duval.

The sacral method. The sacral approach, used by Kraske for carcinoma of the rectum was applied to vesiculectomy by Schede in 1893. With the patient in right lateral decubitus, a median vertical incision is made from the anus to the median portion of the sacral crest. The posterior aspect of the coccyx and sacrum is exposed, particularly the left half. The muscular insertions are detached, and the coccyx and left border of the sacrum resected, following a curved line, starting from the third groove, passing within the fourth, and terminating on the right cornu of the sacrum. The rectum is reclined downward toward the right of the patient, and the solid sacrorectogenital aponeurosis is cut through, exposing the prostatovesicular region, whereupon the vesicles and ampullæ are dissected and removed.

Rydigier's modification. This method involves a temporary bone resection, to be closed after the vesicle is removed. The skin incision starts at the posterosuperior spine of the left ilium, and curves inward over the summit of the coccyx to end at the anus. A flap of sacrococcygeal bone is then cut under the third groove of the sacrum, and is turned back to expose the pelvic cavity. The operation then proceeds as in Kraske's method, but at the end the bony flap is replaced.

The parasacral method. This technic was devised by Baudet and Reyt as a substitute for the sacral approach, to avoid the disadvantages of bone resection. The patient is placed in lateral decubitus on the side opposite the vesicle that is to be removed, with thigh flexed on the pelvis. The skin is incised in a line starting from the top of the coccyx and passing obliquely upward, parallel to the margin of the sacrum, which it follows for about 10 cm. The subcutaneous fibrous tissue, the gluteus maximus, and the great sacrosciatic ligament are cut. The upper part of the levator ani must also be sectioned; if adequate exposure is to be had, it is even necessary to cut a part or all of the coccygeus. The posterior aspect of the rectum is thus revealed. This organ must be reclined downward and freed from fibrous tracts that cause it to adhere to the posterior surface of the prostatoperitoneal bed; this exposes the vesicle, lying deep in the pelvis, about 10 to 12 cm. below the surface. This incision gives an excellent exposure: the vesicular region is in full view, but the vesicles lie so deep that it is difficult to get hold of them.

The coccygoperineal method of Fiolle. The incision is low, with its top at the level of the coccyx and its terminus in the perineal region. It is thus intermediate between the posterior and the inferior modes of approach, but is properly classified among the posterior. The patient is in right lateral decubitus, his rectum empty, but his bladder filled with fluid to force backward the organs which must be reached. The skin incision starts vertically from the internal aspect of the left ischium, becomes oblique, parallel to the great sacrosciatic ligament, then crosses the median line in a horizontal direction, over the sacrococcygeal articulation, to terminate 2 cm. to the right of the latter. The ligaments, muscles, and aponeuroses are incised in the same line successively, from without inward. Some of the upper fibers of the gluteus maximus, the levator ani, and the left coccygeus are cut, after which the coccyx and sacrum are disarticulated, with suitable hemostasis of the lateral sacral vessels. The deep perineal aponeurosis is carefully incised where it lies, like a veil, at the bottom of the wound; it is held to the left side of the incision, lifted up and opened; the left index finger is inserted within the opening, and makes it possible to follow the incision toward the median line, just as the peritoneum is opened in a laparotomy.

The rectum is retracted and isolated along the entire area of the operation, first on its left side, then on its anterior aspect. In the course of this décollement, care must be taken not to section the median hemorrhoidal artery, which will be needed to make repair. The posterior aspect of the prostate and vesicles is now concealed only by the thin aponeurosis of Denonvilliers, which can be broken through with the finger. The vessels of the vas and vesicle are ligated. A large retractor draws down the inferior lip of the incision, while another pushes back the ampulla of the rectum toward the right of the patient. The vessels are clamped close to the organ if they are readily visible; if not, the vesicogenital artery, arising from a trunk common to it and the median hemorrhoidal artery, which has been previously recognized and which separates from the former at a point rather high up, is followed up to its bifurcation, where the vesicodeferential branch should be tied. This is an important ligature, and makes it possible to finish the intervention without being inconvenienced by the bleeding that would otherwise be inevitable.

The vesicular bed is opened with the knife. The ampulla and vesicle are isolated, avoiding the peritoneal cul-de-sac which covers the base of the latter after the organs are resected, and the wound is closed with a drain.

The anococcygeal method. Hunt, of the Mayo Clinic, has proposed the following operation: The patient, in ventral decubitus, is placed on the table with pelvis elevated, and a median rectilinear incision is made from behind the anus to a point 25 mm. from the latter, passing slightly above the sacrococcygeal articulation. The bone is exposed, the anococcygeal raphe cut, and the tip of the coccyx resected. The rectum is isolated and mobilized, separated from the sacrococcygeal concavity and pushed back laterally with a convenient retractor. The retroprostatic region and Denonvilliers' aponeurosis are identified. The vesicle, thus exposed, is easily accessible to maneuvers for the purpose of isolating it, and may be methodically extirpated. If both vesicles require operation, the rectum is pushed over to the opposite side, and the same procedure is followed with reference to the other vesicle. Hunt advises leaving a cigaret drain in the wound and suturing the levatores on the median line between the two muscles. No complications of any kind have been observed following this procedure. This operation differs from the others in employing a shorter incision, in the median region. Although it gives a less ample exposure than other posterior methods, it permits the displacing of the rectum successively to right and to left, according to the needs of the situation.

All these posterior incisions have one great advantage over other methods: they make it possible to reach both vesicles through a single incision, and, unlike the anterior incisions, they allow the operator to work under full vision and see what he is doing. This is especially true of Fiolle's operation. The perineal and posterior approaches also provide the best drainage. It is obvious that the anterior approaches are faulty in this respect, there being no way provided for the gravitational escape of infectious material from the pelvis. The transvesical approach is particularly disadvantageous from this point of view. For nontuberculous inflammation of the vesicles the perineal approach must remain the ideal method, permitting adequate treatment with a minimum of operative risk.

THE AUTHOR'S SERIES OF 100 CONSECUTIVE PERINEAL SEMINAL VESICULECTOMIES WITHOUT A DEATH

During the years 1923 and 1924 the author performed a long series of operations on the seminal vesicles in patients at the New Jersey State Hospital for the purpose of drainage and excision, in an effort to eliminate foci of infection that might underlie their psychotic condition. All cases in which the seminal vesicles were found to be affected with definite pathological lesions were operated upon and the vesicles removed as possible foci of infection. The present series of 100 consecutive cases of vesiculectomies is taken from a longer total series of operations performed by members of the Hospital staff, and is incorporated in this work to illustrate the immediate and later results that may be expected from the perineal method, which was employed in all cases.

Age incidence. The ages of these 100 patients averaged 30.6 years, the youngest being 16 and the oldest 59 years. (See Table I.)

TABLE I

Age Incidence in 100 Consecutive Cases of Seminal Vesiculectomy

From 16 to 19 years	6 cases
" 20 to 30 years	43 "
" 31 to 40 years	26 "
" 41 to 59 years	13 "
Not recorded	12 "
Total	100
Youngest	16 years
Oldest	59 years
Average	30.6 years

Method of vesiculectomy used. The perineal method of surgical approach was employed in all cases, as the safest and most convenient method. (See Figs. 30, 31 and 32.) Being extraperitoneal, extraurethral and extravesical, this method avoids the danger of such common sequels as perineal or rectal fistula, epididymitis, peritonitis, urinary incontinence and the like, which have been frequently mentioned in the literature as the results of other methods of vesiculectomy.

Type of case operated upon. The cases operated upon were all cases of chronic vesiculitis; they embraced 2 with actual pus, and many vesicles that were swollen or much distended, and that did not empty by manipulations during the operation. In these cases it was interesting to find the vesicles bent down and bound by fibrotic adhesions, which made the dissection from the underlying plane very difficult, and indicated the association of an extensive process of perivesiculitis. In some cases the vesicles were plastered to the wall of the bladder and so adherent to the layers of Denonvilliers' aponeurosis that normal drainage was impossible and the lumina of the vesicles were obliterated. Often the obliteration of the lumina of the excretory ducts was due to stenosis of the ejaculatory ducts caused by débris or inflammatory changes.

Histological sections showed more or less thickening of mucous folds as a result of round-cell infiltration and granulation tissue, with some denuding of the mucous membrane along the lining cavity. In other sections the folds became more fibrous, with recesses between them, containing inflammatory exudates, secretion, necrotic cells, and sometimes microörganisms. There was obliteration of the labyrinth or lobules and of the lumina, with thicker fibrotic sheaths, and there were many leukocytes with extensive round-cell infiltration, revealing the extent of the local process of chronic vesiculitis, which served as an active focus of infection for the rest of the body. (See Table II.)

TABLE II

PATHOLOGICAL FINDINGS IN 100 CASES OF SEMINAL VESICULECTOMY

Macroscopic

In two cases, actual pus was found in the vesicles.

Perivesiculitis, swollen vesicles and hypertrophy of walls were of common occurrence.

The lumen of the excretory ducts was obliterated in a few cases by débris and chronic inflammatory process.

Many of the diverticula were found occluded with calcifications and exudates which contained leukocytes.

All cases presented clinical evidence of chronic vesiculitis.

Microscopic

Cultures from specimens removed showed various types of microörganisms, as follows:

Bacillus coli communis
Bacillus aërogenes
Staphylococcus albus
Staphylococcus aureus
Streptococcus viridans
Streptococcus hemolyticus
Streptococcus, unclassified
Staphylococcus, unclassified
Diplococcus
Bacillus diphthericus and pseudodiphthericus

Histological sections from the specimens removed at operation revealed inflammatory changes of chronic vesiculitis.

Postoperative care. In the postoperative care of the author's series of 100 consecutive vesiculectomies done by the perineal route, the stitches were removed at the end of 6 days in nearly all cases, and many patients were out of bed in 10 or 12 days. If any gauze packings were used because of persistent oozing or bleeding, these were removed, together with the cigaret drainage, between the third and fourth day after operation, in order to save days of convalescence in the surgical ward. Every patient received an ounce of castor oil and a rectal enema on the third or fourth day following operation, and every wound was dressed daily. The time that these patients stayed in the surgical wards after the vesicle operations were carried out varied from 12 days to 4½ weeks, the average time being 2 weeks. No complications of any importance were encountered, and the few wounds that were infected recovered promptly.

Late results of surgery of the seminal vesicles, as observed in the author's series after 5 to 6 years. *Functional results.* When the vesicles are removed under full vision and the ampullæ are not torn, the connection of the lumen of the vasa deferentia remains patent and therefore the spermatic function is not disturbed, provided, of course, that the ejaculatory ducts are patent. The ampulla or remaining portion of the tract gradually becomes distended after vesiculectomy and undergoes a compensatory hypertrophy, so that it finally assumes the physiological function of the vesicle and becomes, in turn, the reservoir of the semen, with the same power of expulsion during the ejaculation that was previously exerted by the vesicle. This it can do because it has from the beginning the same anatomical disposition as the seminal vesicle itself, and when the vesicle becomes diseased or obliterated, or is excised surgically, the ampulla, by its normal physiological process, becomes capable of replacing the vesicle and performing the functions proper to the latter. Hence, the removal of both seminal vesicles in this type of chronic vesiculitis does not alter either the genital integrity or the spermatic function. (See Table III.)

Anatomical results. On reëxamination of these patients, 5 or 6 years after seminal vesiculectomy was performed, the ampullæ were found to be patent and easily palpable in more than 21 per cent. of the cases. The external genitals were normal, or were the same as before operation, in practically all cases. The scar of the perineal wound was firmly healed in every case. Rectal examination showed the prostate gland normal in size and consistency in about 80 per cent. of the cases. In a few cases, however, this organ was boggy, leathery, or irregularly shaped, and some had adhesions or rectal attachment. Ten per cent. of the cases examined showed

TABLE III

Findings at Reëxamination of 100 Cases of Perineal Seminal Vesiculectomy 5 to 6 Years After Operation

Ninety-two patients were still alive and of these 71 were reëxamined and found free from urinary symptoms. Eight patients had died from causes unrelated to the operation, and 21 were not traced but were apparently doing well.

Of the 8 deaths, 2 were due to lobar pneumonia, 2 to pulmonary tuberculosis and 4 to constitutional diseases and causes unrelated to the operation, as is shown by the fact that the average time between the operation and the death was 2 years and 3 months, and that in no case did death occur less than 10 months after operation.

The duration of stay in the surgical ward was from 12 days to 4½ weeks, the average time being 2 weeks.

External genitals were normal or the same as before operation in practically all cases.

The scar of the perineal wound was firmly healed in every case.

Rectal examination showed prostate normal in about 80 per cent. of cases. Slightly hypertrophied or adenomatous prostate was found in 10 per cent. of cases, but no urinary symptoms were present.

The ampullæ were palpable in 21 per cent. of cases.

The vasa deferentia were within normal limits in almost every case.

Sexual potency had remained apparently unchanged in most instances.

A definite fibrotic band running from right to left at the base of the prostate was found in 5 per cent. of cases, due to loose or unsutured Denonvilliers' aponeurosis.

Not a single case of urinary incontinence was observed in this series; the urinary control was perfect in all cases.

slightly hypertrophied or adenomatous conditions by the rectal touch, but clinically these were of no consequence since no urinary symptoms were present.

In 5 per cent. of the cases a peculiar fibrotic band of tissue was found by rectal examination at the base of the prostate, running from the right to the left side of the median line. Sometimes it was easily palpable and extended beyond the prostate at the base of the bladder, giving a definite impression of being the remaining layers of Denonvilliers' aponeurosis which were loose in the recto-vesical space, as if they had not been sutured to the apex of the prostate, as illustrated in Figure 32. These bands of adhesions were of no particular significance except that they made palpation of the ampullæ impossible, and thus showed the importance of preserving all layers of fascia and lines of cleavage. These should be reconstructed and sutured in a proper way, just as in any other operation. (See Tables III and IV.)

Table IV shows the surgical and later results of the 100 consecutive perineal seminal vesiculectomies without a death, performed by the author at the New Jersey State Hospital during the years 1923 and 1924, and reëxamined 5 to 6 years later.

TABLE IV

A Summary of 100 Consecutive Cases Operated upon for Seminal Vesiculectomy

Case No.	Name	Age	*Urological Findings* in Seminal Vesicles	Date of Operation	Surgeon	Type of Operation	Pathological Findings	Surgical Results	Reëxamination and Results 5-6 Years Later
1	P. B.	24	R.+++ L.++	10-22-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Wound healed without complications.	Testes normal. Prostate normal in size and consistency. Right and left ampullæ easily palpable. Urine clear.
2	G. K.	?	R.+++ L.++	4-4-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis. Culture shows Bacillus coli communis.	Recovered rapidly. Perineal wound healed firmly.	Left hospital. Apparently doing well.
3	E. M.	26	R.++++ L.++	1-17-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good recovery. Perineal wound closed in two weeks.	Genital organs normal; no symptoms.
4	D. M.	36	R.+++ L.++	9-10-23	Gutierrez	Seminal Vesiculectomy	Bacillus coli Staphylococcus albus	Perineal wound healed firmly.	Testes normal. Vas deferens normal. Right and left ampullæ easily palpable. Prostate normal in size and consistency.
5	S. M.	23	R.++++ L.++++	4-11-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Sutures removed after sixth day. General appearance improved.	Left hospital. Apparently doing well.
6	A. M.	33	R.++++ L.+++	3-28-23	Gutierrez	Seminal Vesiculectomy	Vesicle much enlarged and chronically inflamed	Good recovery. General condition good.	Left hospital. Apparently doing well.
7	G. A. C.	28	R.+++ L.++	5-2-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed without incident. Good condition.	External genitals normal. Testes, vas deferens and epididymis normal. Prostate normal. Ampullæ palpable.
8	T. J. F.	28	R.+++ L.++	5-2-23	Gutierrez	Seminal Vesiculectomy	Vaccine started 4-10-23	Good recovery. Perineal wound healed without incident.	Left hospital, free from symptoms.
9	D. C.	59	R.++++ L.+++	4-25-23	Gutierrez	Seminal Vesiculectomy	Culture shows Bacillus coli communis	Recovery without incident. Perineal wound healed in 12 days.	Free from urogenital disorders.
10	G. A.	36	R.++++ L.+++	6-20-23	Gutierrez	Seminal Vesiculectomy	Streptococcus viridans	Perineal wound healed firmly.	External genitals normal. Testis and vas deferens normal. Prostate normal. No adhesions to rectal wall. Urine clear.
11	G. M.	30	R.++++ L.++++	7-11-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Wound healed in two weeks.	Left hospital, free from symptoms.
12	J. T.	19	R.++++ L.++++	7-11-23	Gutierrez	Seminal Vesiculectomy	Streptococcus Bacillus coli	Scar of perineal wound is clean and firmly healed.	Testes normal. Prostate irregularly enlarged, the right lobe protrudes and is adenomatous in type. Ampullæ are not palpable. Some attachment to rectal walls. Urine clear.
13	G. E.	31	R.++++ L.+++	6-27-23	Gutierrez	Seminal Vesiculectomy	Hypertrophy of walls. Many leukocytes; chronic vesiculitis.	Recovered nicely.	Testes normal. Prostate normal, vas deferens and epididymis normal. No adhesions to rectal wall. Ampullæ palpable.
14	W. W.	21	R.+++ L.++	6-27-23	Gutierrez	Seminal Vesiculectomy	Bacillus coli	Perineal wound healed without complications.	Left hospital, apparently doing well.
15	G.M.H.	21	R.++++ L.+++	6-20-23	Gutierrez	Seminal Vesiculectomy	Staphylococcus aureus	Good recovery from operation. Perineal wound healed firmly.	External genitals normal. Testis, vas deferens and epididymis normal. Prostate slightly enlarged. Contour irregular. Ampullæ not palpable. No rectal adhesions. Urine clear.
16	M. S.	?	R.++++ L.+++	6-13-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	External genitals normal. Penis large, due to masturbation. Testis, vas deferens and epididymis normal. Prostate enlarged. Right lobe and fibrotic band from right to left at base of prostate. Urine clear.
17	D. S.	?	R.++++ L.++++	5-21-23	Gutierrez	Seminal Vesiculectomy	Staphylococcus aureus	Recovery without incident.	Left hospital, free from symptoms.

TABLE IV (Cont'd)

Case No.	Name	Age	*Urological Findings* in Seminal Vesicles	Date of Operation	Surgeon	Type of Operation	Pathological Findings	Surgical Results	Reëxamination and Results 5–6 Years Later
18	W. W.	?	R.++++ L.++++	5–16–23	Gutierrez	Seminal Vesiculectomy	Culture positive for Bacillus coli communis	Both vesicles removed without complications. Wound closed in 2 weeks.	Left hospital, apparently doing well.
19	L. S.	?	R.++ L.++++	5–16–23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Excellent.	Left hospital, free from symptoms.
20	J. S.	?	R.++++ L.+++	5–16–23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Recovered rapidly. Wound healed in 10 days.	No genito-urinary disturbance.
21	M. O.	22	R.++++ L.++++	4–16–23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good recovery.	Discharged from hospital. Apparently doing well.
22	J. S.	16	R.+++ L.++	11–21–23	Gutierrez	Seminal Vesiculectomy	Streptococcus, Bacillus coli, Bacillus aerogenes	Perineal wound healed firmly without incident	External genitals normal. Testes, vas deferens and epididymis also normal. Prostate gland normal in size and consistency. Ampullæ not palpable.
23	A. I. C.	23	R.++++ L.++++	11–14–23	Gutierrez	Seminal Vesiculectomy	Culture showed no growth of microörganisms	Perineal wound healed firmly without incident in 12 days.	Testes normal, vas deferens normal. Prostate leathery in consistency. Ampullæ not palpable. Hard fibrotic band running from right to left side at base of prostate.
24	P. T.	29	R.+++ L.++++	11–14–23	Gutierrez	Seminal Vesiculectomy	Lumen of duct filled with mucopurulent fluid with many leucocytes present. Chronic vesiculitis	Perineal wound healed firmly.	External genitals normal. Testes normal in size and consistency. Vas deferens and epididymis normal. Prostate slightly enlarged, leathery in consistency. Ampullæ not palpable. No adhesions to rectal wall. Urine clear.
25	C. C.	26	R.++++ L.+++	11–10–23	Gutierrez	Seminal Vesiculectomy	Contaminated	Wound entirely healed without complications.	Testes normal. Prostate enlarged++ in size consistency and contour. Both ampullæ palpable. Glans penis unusually developed, due probably to chronic masturbation.
26	J. J.	28	R.++++ L.++	11–5–23	Gutierrez	Seminal Vesiculectomy	Streptococcus hemolyticus	Good surgical recovery. Wound healed in 2 weeks.	External genitals normal. Both testes, vas deferens and epididymis normal. Rectal examination shows prostate negative. Both ampullæ palpable. Urine clear.
27	L. L.	33	R.++++ L.+++	10–24–23	Gutierrez	Seminal Vesiculectomy	Staphylococcus albus	Perineal wound healed firmly without incident.	Testes normal. Prostate small in size and free from rectal adhesions. Both ampullæ slightly palpable.
28	H.McG.	32	R.++++ L.+++	10–17–23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly without incident.	Testes normal. Slight bilateral varicocele. Ampullæ easily palpable. Prostate normal in size and consistency.
29	J. T. W.	29	R.+++ L.++	10–10–23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Some bleeding. Wound repacked 10–11–23. Good recovery. Healed without fistula in three weeks.	Died 3–15–29 from pneumonia. No urinary disturbance during 6 year period preceding death.
30	M. D.	37	R.+++ L.++	10–8–23	Gutierrez	Seminal Vesiculectomy	Staphylococcus aureus	Good recovery.	6–17–26 Sputum culture positive for tuberculosis. Died 4–1–29. Pulmonary tuberculosis.
31	N. R.	30	R.++++ L.+++	10–3–23	Gutierrez	Seminal Vesiculectomy	Contaminated	Catheterized until 10–6–23. Good recovery. Perineal wound healed firmly.	External genitals normal. Testes, vas deferens and epididymis normal. Prostate normal in size and consistency. Slight protrusion of left lateral lobe. No rectal attachment. Ampullæ not palpable.

TABLE IV (Cont'd)

Case No.	Name	Age	*Urological Findings* in Seminal Vesicles	Date of Operation	Surgeon	Type of Operation	Pathological Findings	Surgical Results	Reëxamination and Results 5-6 Years Later
32	A. K.	23	R.++++ L.++	10-1-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Some bleeding for 3 days. Repacked twice. No bleeding after 4th day. Good recovery. Wound healed in 3 weeks.	Testes small but normal in consistency; perineal scar healed firmly. Prostate negative. Ampullæ not palpable.
33	J.McM.	29	R.++++ L.+++	10-31-23	Gutierrez	Seminal Vesiculectomy	Staphylococcus albus	Good recovery; perineal wound healed firmly.	Died 2 years after operation.
34	E. M.	32	R.++++ L.+++	9-24-23	Gutierrez	Seminal Vesiculectomy	Staphylococcus albus	Perineal wound healed firmly.	Died 2½ years after operation.
35	J. H.	19	R.+++ L.++	9-5-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Restless for 4 days. Some bleeding. Quiet after 4th day. Perineal wound healed firmly.	Testes and vas deferens normal. Right ampulla hard. Hypertrophy of right prostate lobe. Left lobe of prostate small.
36	A. J. C.	31	R.+++ L.++	9-5-23	Gutierrez	Seminal Vesiculectomy	Staphylococcus albus and streptococcus	Perineal wound healed firmly without incident.	Right and left ampullæ palpable. Prostate slightly enlarged, particularly at left lobe, leathery in consistency. Testes normal, vas deferens also normal.
37	N. N.	?	R.++++ L.+++	9-5-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good recovery. Perineal wound closed in 12 days.	Has been working ever since; free from urogenital disorders.
38	H. M.	31	R.++++ L.++++	6-13-23	Gutierrez	Seminal Vesiculectomy	Culture shows Bacillus coli communis	Perineal wound healed firmly.	External genitals normal. Testes normal. Right epididymis slightly enlarged, nodular and indurated. Prostate slightly enlarged. Ampullæ palpable.
39	W.DuB.	46	R.+++ L.++++	4-18-23	Gutierrez	Seminal Vesiculotomy Prostatotomy	Chronic vesiculitis	Perineal wound healed firmly without incident.	Free from urinary and genital disorders.
40	R. G.	27	R.+++ L.++++	3-17-24	Gutierrez	Seminal Vesiculotomy	Chronic vesiculitis	Good recovery.	Genito-urinary examination 11-2-26 shows absence of all disorders.
41	J.DeM.	20	R.+++ L.+++	3-3-24	Gutierrez	Seminal Vesiculectomy	Had vaccines made from vesicle culture. Staphylococcus albus. Streptococcus.	Good recovery.	Left hospital free from symptoms.
42	J. D.	25	R.++ L.+++	3-3-24	Gutierrez	Seminal Vesiculectomy	Had vaccines made from vesicle culture of staphylococcus.	Good recovery. Perineal wound healed nicely.	External genitals normal. Testes and epididymis and vas deferens normal. Prostate smaller than usual. Both ampullæ palpable. No rectal adhesions.
43	J. L.	34	R.++++ L.+++	2-27-24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Wound healed firmly in two weeks.	Left hospital. Apparently doing well.
44	H. D.	25	R.++ L.++++	2-25-24	Gutierrez	Seminal Vesiculectomy	Had vaccines made from vesicle culture of Staphylococcus albus	Perineal wound healed firmly without incident.	Both testes small. Normal in consistency. Marked varicocele on both sides of scrotum. Prostate smaller than usual. Right ampulla slightly palpable. Left not palpable.
45	C. L. R.	38	R.+++ L.+++	2-18-24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good surgical recovery.	Left hospital, apparently doing well.
46	J. B.	24	R.+++ L.+++	2-18-24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed without incident in 10 days.	Left hospital, free from symptoms.
47	N. B.	43	R.+++ L.+++	2-13-24	Gutierrez	Seminal Vesiculectomy	Had vaccines made from vesicle culture of Staphylococcus aureus.	Perineal wound healed nicely.	External genitals normal, testes normal. Vas deferens palpable on both sides. Slight external hemorrhoid present. Sphincter tight. Prostate normal. Ampullæ palpable.
48	B. E.	27	R.+++ L.+++	2-11-24	Gutierrez	Seminal Vesiculectomy	Staphylococcus albus	Good recovery.	Discharged from hospital, free from symptoms. Right vesicle normal.

TABLE IV (Cont'd)

Case No.	Name	Age	*Urological Findings* in Seminal Vesicles	Date of Operation	Surgeon	Type of Operation	Pathological Findings	Surgical Results	Reëxamination and Results 5-6 Years Later
49	A. H.	22	R.++ L.++++	2-4-26	Gutierrez	Seminal Vesiculectomy	Culture taken. No growth of microörganisms.	Perineal wound healed firmly without incident.	Left testis half normal size. Both vasa deferentia palpable. Prostate leathery in consistency and normal in size. Ampullæ not palpable. Fibrotic band from right to left at base of prostate.
50	A. A.	19	R.+++ L.+++ Masturbation	2-4-24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good recovery.	Left hospital in good condition.
51	J. D.	26	R.+++ L.++++	2-4-24	Gutierrez	Seminal Vesiculectomy	Bacillus coli. Vaccine made and administered.	Good recovery.	Left hospital. Apparently in good condition.
52	S. H.	20	R.+++ L.+++	3-17-24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good recovery.	Died, 7-14-25 of lobar pneumonia, 1½ years after operation.
53	T. C.	32	R.+++ L.+++	2-11-24	Gutierrez	Seminal Vesiculectomy	Vaccine given from vesicle culture of Staphylococcus albus	Good surgical recovery.	Died 7-9-26, of pulmonary tuberculosis, nearly three years after operation.
54	J. McC.	55	R.++++ L.++	4-18-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Uneventful surgical recovery.	Died 12-25-24 of chronic myocarditis arteriosclerosis 10 months after operation.
55	F. B.	25	R.++++ L.+++	2-20-24	Gutierrez	Seminal Vesiculectomy	Vaccine given from vesicle culture of Streptococcus equinus & Streptococcus mitis.	Surgical recovery good.	Discharged from hospital, free from symptoms.
56	W. B.	49	R.++ L.++++	2-25-24	Gutierrez	Seminal Vesiculectomy	Vaccine given from vesicle culture of Staphylococcus aureus.	Satisfactory.	Left hospital. Apparently doing well.
57	H. J.	39	R.++++ L.+++	12-17-23	Gutierrez	Seminal Vesiculectomy	Streptococcus mitis and Bacillus coli.	Satisfactory.	Died 11-25-27 of diarrhea and nephritis, 4 years after operation.
58	M. S.	?	R.+++ L.++++	3-10-14	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good recovery.	No genito-urinary disorders.
59	J. V.	31	R.+++ L.++++	1-7-24	Gutierrez	Seminal Vesiculectomy	Bacillus coli	Perineal scar healed entirely and firmly without incident.	Testes normal, vas deferens normal, prostate small but normal in consistency. Ampullæ not palpable. No rectal attachment.
60	H. M.	27	R.++++ L.+++	12-17-23	Gutierrez	Seminal Vesiculectomy	Bacillus coli	Perineal wound healed firmly.	Scar of abdominal operation. External genitals normal. Both testes normal in size and consistency. Vas deferens and epididymis normal. Ampullæ not palpable. No rectal adhesions.
61	W. C.	33	R.++++ L.+++	3-10-24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly without incident.	Prostate slightly boggy, about normal in size and consistency. Ampullæ not palpable.
62	S. E.	26	R.+++ L.+++	?	Gutierrez	Seminal Vesiculectomy	Staphylococcus albus	Perineal wound healed firmly.	Prostate normal. Definite fibrotic band from right to left at base of prostate. Ampullæ not palpable. Urine clear.
63	S. F.	24	R.++++ L.+++	8-6-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Scar of perineal wound healed firmly without incident.	Testes normal, prostate normal in shape and size, slightly fibrotic. Both ampullæ are easily palpable and normal.
·64	J. M.	27	R.++++ L.+++	9-12-23	Gutierrez	Seminal Vesiculectomy	Section of vesicles shows chronic vesiculitis	Perineal wound healed firmly without incident.	Testes normal in size and consistency. Prostate negative. Ampullæ not palpable. Rectal wall free from adhesions.
65	W. S.	33	R.+++ L.++	1-14-24	Gutierrez	Seminal Vesiculectomy	Culture shows staphylococcus and streptococcus	Perineal wound healed firmly. Closed in 12 days.	Testes normal in size and consistency. Prostate slightly enlarged but normal in consistency. Ampullæ slightly palpable. No rectal attachment.

TABLE IV (Cont'd)

Case No.	Name	Age	*Urological Findings* in Seminal Vesicles	Date of Operation	Surgeon	Type of Operation	Pathological Findings	Surgical Results	Reëxamination and Results 5–6 Years Later
66	M. D.	44	R.+++ L.++++	2–20–24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound clean and healed firmly without incident.	Prostate boggy and slightly enlarged. Free from rectal attachment. Ampullæ not palpable.
67	Z. V.	36	R.+++ L.+++	1–16–24	Gutierrez	Seminal Vesiculectomy	Culture taken. No growth obtained	Perineal wound firmly healed.	Prostate normal. Both ampullæ palpable. Vasa deferentia, testes and epididymides normal.
68	W. B.	25	R.+++ L.+++	1–16–24	Gutierrez	Seminal Vesiculectomy	Culture taken. No growth obtained	Perineal wound firmly healed.	Testes normal in size and consistency. Vasa deferentia palpable and normal. Prostate normal in size, leathery in consistency. Ampullæ not palpable.
69	P. F.	19	R.++++ L.+++	?	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly without incident.	External genitals normal. Testes, vasa deferentia and epididymides normal. Prostate normal. Ampullæ not palpable.
70	G. D.	24	R.++ L.++++	4–2–24	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound firmly healed.	External genitals normal. Testes, vasa deferentia and epididymides normal. Prostate normal. Ampullæ not palpable.
71	W. G.	30	R.++++ L.+++	1–23–24	Gutierrez	Seminal Vesiculectomy	Culture showed no growth of microörganisms.	Perineal wound healed firmly.	Prostate normal in size and consistency. Ampullæ not palpable. Testes, vasa deferentia and epididymides normal.
72	L. D.	?	R.++++ L.+++	6–12–24	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	External genitals normal. Testes normal. Walls of vas deferens palpable and normal. Slight external hemorrhoid present. Ampullæ palpable. No rectal adhesions.
73	E. S.	32	R.+++ L.+++	1–21–24	Gutierrez	Seminal Vesiculectomy	Sections of vesicles show chronic vesiculitis.	Perineal wound firmly healed in 2 weeks time.	External genitals normal. Testes, epididymis and vas deferens normal. Prostate twice usual size, boggy in consistency. Ampullæ palpable. Slight fibrotic band from right to left at base of prostate.
74	A.DeC.	20	R.++++ L.+++	5–14–23	Gutierrez	Seminal Vesiculectomy	Culture shows presence of Bacillus coli communis.	Stitches removed in 6 days. Good recovery.	Discharged from hospital. Apparently doing well.
75	T. J. F.	28	R.++++ L.+++	5–2–23	Gutierrez	Seminal Vesiculectomy	Culture showed no growth of microörganisms.	Perineal wound clean. Uneventful recovery.	Free from urinary disorders.
76	W. C.	42	R.++ L.+++	9–17–23	Gutierrez	Seminal Vesiculectomy	Culture shows streptococcus and staphylococcus.	Wound closed firmly without complications.	Working and apparently well.
77	H. B.	34	R. ? L. ?	4–9–20	Smith	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	Has been working since, free from urinary disorders.
78	E. J. C.	32	R.++++ L.++++	12–19–19	Smith	Seminal Vesiculectomy	Culture shows streptococcus and staphylococcus.	Perineal wound healed firmly without complications.	Patient recovered and is free from urinary disorders.
79	W. K.	?	R.+++ L.+++	4–12–23	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis.	Uneventful recovery. Perineal wound healed firmly.	Prostate negative. External genitals negative. Testes, epididymides and vasa deferentia normal. Ampullæ palpable.
80	C. K.	16	R.+++ L.++	6–20–23	Gutierrez	Seminal Vesiculectomy	Vesicles much distended. Staphylococcus albus.	Perineal wound healed firmly.	Left hospital, free from symptoms.
81	J. L.	40	R.++++ L.+++	9–20–22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis and perivesiculitis	Perineal wound healed firmly. Uneventful recovery.	No urinary disturbances.
82	G. M.	23	R. L.	2–7–23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	No genito-urinary disturbances.

TABLE IV (Cont'd)

Case No.	Name	Age	*Urological Findings* in Seminal Vesicles	Date of Operation	Surgeon	Type of Operation	Pathological Findings	Surgical Results	Reëxamination and Results 5-6 Years Later
83	R. R. B.	33	R.+++ L.++++	9-2-22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	No genito-urinary disturbances.
84	F. T.	?	R. L.	12-13-22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	Stitches removed on the 6th day. Perineal wound healed firmly.	Discharged from hospital. Apparently in good condition.
85	J. C.	24	R. L.	10-12-22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	2-9-27 Sphincter normal. Adherence to rectum, mucosal region. Prostate normal.	Left hospital, free from symptoms.
86	J. L.	31	R.++++ L.+++	5-7-22	Gutierrez	Seminal Vesiculectomy	Right vesicle, Staphylococcus aureus. Left vesicle Staphylococcus albus	Perineal wound closed in the usual time without incident.	Improvement in general health; no genito-urinary troubles.
87	F. G.	39	R.++++ L.+++	1-19-22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly without incident.	Left hospital. Apparently doing well.
88	R. B.	24	R.++++ L.+++	9-20-22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	Left hospital, free from genito-urinary disorder.
89	J. B.	30	R.+++ L.++++	11-15-12	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly. Good results.	Left hospital. No genito-urinary troubles.
90	J. A.	59	R.++++ L.+++	3-29-22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	Left hospital. Apparently doing well.
91	F. P.	39	R.+++ L.++++	10-4-22	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly. Good results.	Left hospital. Apparently doing well.
92	J. A. C.	28	R.+++ L.++++	4-14-24	Gutierrez	Seminal Vesiculectomy	Culture shows streptococcus and staphylococcus.	Wound healed firmly without incident.	Rectal examination shows prostate negative, both ampullæ palpable. External genitals normal.
93	E. J.	?	R.+++ L.++++	12-18-23	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly without complications.	Left hospital. No genito-urinary disturbances.
94	C. B.	20	R.+++ L.+++	9-6-22	Morrissey	Seminal Vesiculectomy	Chronic vesiculitis	Perineal wound healed firmly.	Left hospital. Apparently doing well.
95	M. B.	42	R.+++ L.++++	4-5-22	Morrissey	Seminal Vesiculectomy Prostatotomy	Chronic vesiculitis	Perineal wound healed firmly.	Testes normal, prostate normal. Epididymis and vas deferens normal. Ampullæ not palpable.
96	J. W.	43	R.++++ L.+++	5-10-22	Gutierrez	Seminal Vesiculectomy	Chronic vesiculitis	Good recovery.	Now working on farm; no genito-urinary disturbances.
97	T. W.	49	R.+++ L.++++	12-10-24	Gutierrez	Seminal Vesiculectomy	Localized vesiculitis in one section	Perineal wound healed firmly without incident.	Gained 25 pounds since operation. Condition excellent.
98	W. H.	43	R.++++ L.+++	11-26-24	Gutierrez	Seminal Vesiculectomy	Diplococcus	Uneventful recovery.	Discharged from hospital. Apparently doing well.
99	D. B. H.	28	R.+++ L.++++	11-10-24	Gutierrez	Seminal Vesiculectomy	Lumen of duct filled with mucopurulent fluid. Leukocytes. Chronic vesiculitis.	Wound healed firmly. Good results.	General health improved; no genito-urinary disturbances.
100	C. N.	45	R.++++ L.+++	10-22-24	Gutierrez	Seminal Vesiculectomy	Hypertrophy of walls. Hyperemia. Vesiculitis.	Perineal wound healed firmly without incident.	No genito-urinary disturbances.

COMMON COMPLICATIONS THAT MAY FOLLOW POORLY EXECUTED OPERATIONS

Among complications easily arising as the result of poorly executed operative measures upon the seminal vesicles may be mentioned peritonitis, cystitis, vasitis, epididymitis, epididymo-orchitis, perineal fistula, vesical fistula, rectal fistula, and urinary incontinence. Where there is poor exposure or inadequate provision for drainage, there is every opportunity for surgical accident, resulting in one or more of these complications. Transvesical vesiculectomy offers conditions easily culminating in cystitis or vesical fistula. Improper care of the rectal wall invites rectal fistulæ. The absence of free drainage in a downward direction readily leads to spread of infection after many of the procedures here described, which may cause any of the conditions just mentioned, or may result in abscess formation with perineal fistula. Because of these possible complications, the author is strongly convinced of the advantages of perineal vesiculectomy as the method of choice in chronic vesiculitis as well as in tuberculosis and other surgical conditions calling for extirpation of the vesicles.

VESICULECTOMY AFTER VESICULOTOMY

In some instances indications may exist for the total removal of the seminal vesicles after any type of operation previously performed upon this viscus. Some time ago the author had occasion to operate upon a case of this kind in which Dr. Fuller had performed his ischiorectal vesiculotomy 20 years before, after which, however, the patient had continued to suffer with so-called incurable prostatovesiculitis. He was a man in the early fifties and had for many years been visiting various genito-urinary clinics for his chronic vesiculitis, where he had been receiving routine urological treatment, but without benefit. Upon examination by rectal palpation the two vesicles, inflamed and distended, could be felt as an irregular mass, densely adherent to Denonvilliers' aponeurosis; they were incapable of being emptied by stripping and the secretion obtained revealed over 40 per cent. of pus cells per high power field. In this patient I performed a perineal seminal vesiculectomy, with the result that he is today entirely free from symptoms and is able to lead a normal life. The technic for this secondary operation on the vesicles is the same as that in the primary procedure already described, except that, like any other secondary surgical procedure, it is more difficult and laborious on account of the many additional adhesions and scar tissue that have formed around the vesicles and between the bladder at the rectum.

CHAPTER XI

OPERATIONS UPON THE VASA DEFERENTIA

Operations upon the vasa deferentia fall naturally into two groups, according to their purpose: (1) operations for the purpose of eradicating infection; (2) operations for the relief of sterility.

I. OPERATIONS FOR THE ERADICATION OF INFECTION

In this group fall, first of all, the various punctures and incisions of the vas that have been devised with a view to draining the seminal vesicles and vasa and injecting antiseptic fluids to clean up the infection, both in the vesicles and in the vasa.

SURGICAL DRAINAGE OF THE VAS

Vasostomy (Belfield's operation). In vasostomy, the vas deferens is surgically exposed and then incised for the purpose of permitting irrigation of the spermatic tract and, more particularly, of the vesicles. This operation was first done by Belfield in 1905 and had a wide vogue for a number of years. Belfield operated under local anesthesia, but many surgeons today prefer general anesthesia for the perfect relaxation that it gives during certain manipulations that are rather delicate. The skin incision is made at the root of the scrotum. The vas is readily exposed and exteriorized for 2 to 3 cm. of its length. The spermatic cord is caught up between two pairs of forceps by the left index finger, while an incision of half a thumb's length is made as far as the sheath of the vas, which is opened with care, the vas drawn out and incised longitudinally. (See Fig. 37.) A thread or horsehair may then be introduced into the cavity, toward the vesicle, in order to discover whether or not it is patent. After the patency has been established, a silver cannula or other blunt type of needle attached to a small syringe is introduced into the vas, and the solution to be used is slowly injected. In his early injections Belfield left the cannula *in situ* with a view to facilitating later injections. At a later time he modified this procedure by fixing the two lips of the incision to the integuments and leaving a permanent horsehair in the lumen of the vas. The catheter is introduced upon this horsehair as a guide each time, similarly to the procedure used in urethrotomy. Belfield repeated the injections daily, and some of his followers do it twice a day; this may be continued for 1 to 3 weeks. The original antiseptic injected was collargol. Others have used silver nitrate, boric acid, sodium bicarbonate, acriflavine, protargol, mercurochrome, argyrol, lactate of silver, and fluoride of silver. As to the amount of fluid to be injected, Belfield thought

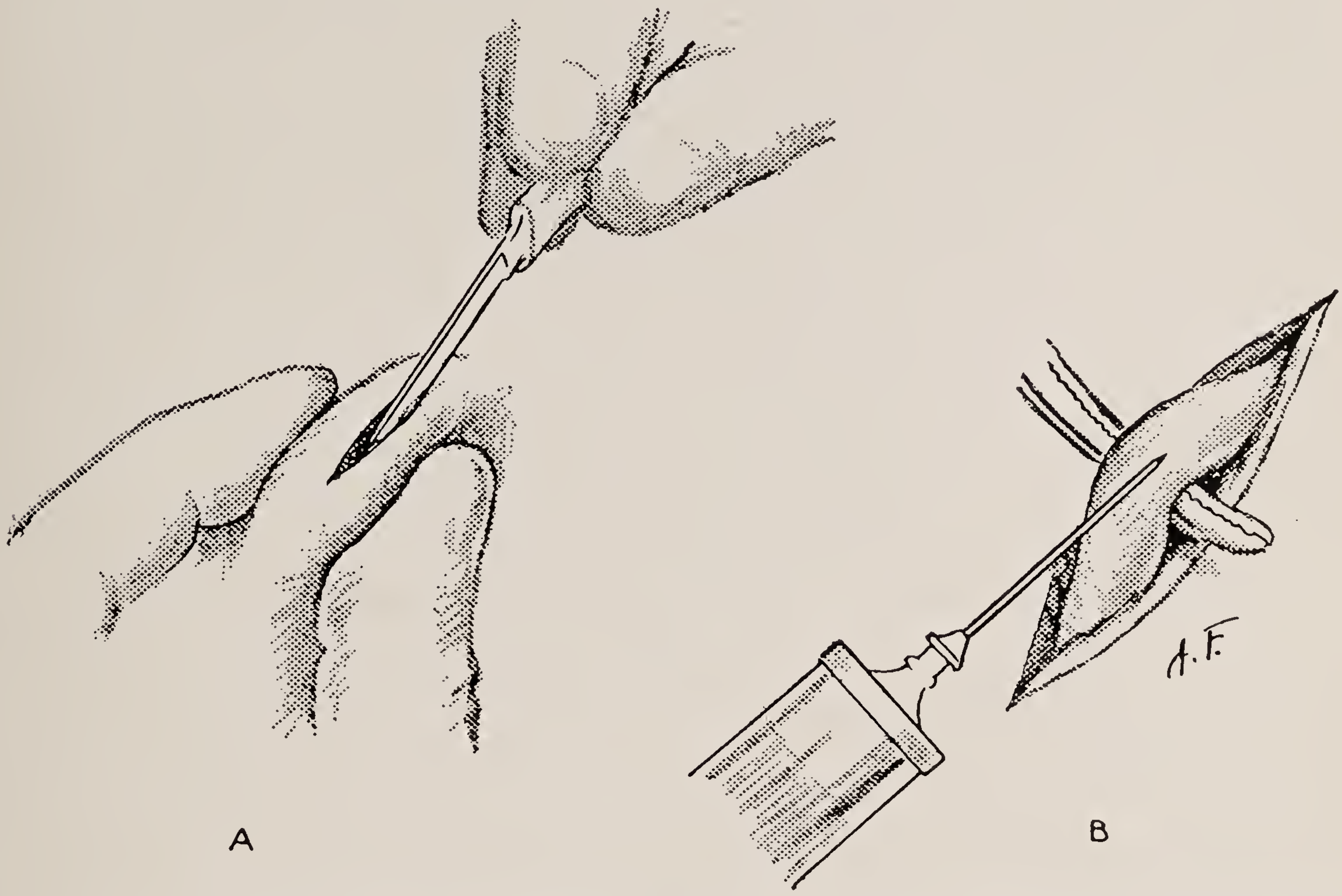


Fig. 37. Technic of vasostomy and vasopuncture for irrigation of the seminal vesicles.

A. The vas deferens is held between the index finger and thumb at the level of the scrotum and an incision made in the skin.

B. The vas is isolated from the other elements of the cord and brought out through the incision. A forceps is inserted under it to hold it in place, while either an incision or a puncture with a needle is made, previous to injection of an antiseptic solution.

This method has been used not only for irrigation of the seminal vesicles but also for the purpose of vesiculography. It was first used in treatment of chronic vesiculitis by Belfield, and has since been modified by Kidd, Luys, B. A. Thomas, and others.

from his experiments that the vesicle and vas together do not hold more than 3 to 6 cc., but as repletion of the vesicles is necessary and an overflow into the urethra or bladder absolutely harmless, there appears to be no reason to fear using larger amounts, since the excess runs off into the posterior urethra and bladder; in fact, there is sound reason for using an amount safely beyond the capacity of the organs, say 10 to 12 cc.

Vas puncture (vasotomy). In 1920 Belfield described under the name of *vas puncture* another procedure, the name of which he later changed to *vasotomy*, somewhat against his will. It differs from the former procedure chiefly in that the vas is incised without being drawn out of its sheath. To make sure that the needle (which replaces the cannula) has actually entered the vas, a solution of methylene-blue 1:25,000 is first injected. If this appears in the urine shortly afterwards, the operation proceeds; if it fails to appear, the technic has been at fault and must either be improved or given up. In more than 1 per cent. of Minet's cases the vas was found to be obliterated. This precaution is well taken, for if the collargol or other solution intended for the vas is, through error, injected into the connective tissue, a painful tumefaction results which is slow to disappear, remaining either in the cord or superficially under the skin, but capable of causing grave infection.

Kidd's modification of Belfield's method. Kidd and others observed that the attempts to leave a cannula in the vas led to reflux of the chemical injected and sometimes to subsequent stricture formation. It occurred no matter what antiseptic was used. It was not the nature of the antiseptic, but the reflux into the interstitial tissues that caused the stricture, leading to sterility. By Kidd's modification this could not occur. The vas, on being lifted out of the cord through the incision of the latter, is supported on the handle of a scalpel, which is gently insinuated under it to keep it well out of the wound and clear of the surrounding tissue sheaths, an important point. With a fine-pointed tenotome a tiny opening is made in a longitudinal direction through the wall of the vas so as to expose its lumen. This is the most delicate part of the operation. The patency of the vas is then tested with a stiff length of fine silkworm gut, which should be able to pass some 10 inches toward the vesicle. If inflammatory stricture or occlusion from any cause is found, it may be well to stop the procedure right here. If, however, the vas is patent, a thin sling of gauze is inserted under the handle of the knife to steady it and catch any escaping fluid. A blunted needle (gauge 20), attached to a well-fitting syringe filled with 10 cc. of a 5 per cent. colloid silver solution, is insinuated into the lumen, with great care not to rub up the mucous membrane with the point of the syringe. If 5 cc. flows in easily, another 5 cc. is injected. After a pause the syringe is removed and the opening in the vas very carefully closed with 1 or 2 00 catgut sutures. These should take up only the outer coat of the vas, and should effectually prevent all reflux of the chemical injected. The vas is then dropped back into place and the skin united with a catgut stitch. One injection is usually enough for a cure. If another is necessary, it can be made a week or 10 days later at a site a little higher up. In this way, risk of stricture and sterility is avoided and the desired result is obtained.

Luys' vasopuncture. The *vasopuncture* of Luys (not to be confounded with the *vas puncture* of Belfield and Kidd) differs from the last-named procedure in that, after exposure of the vas through a minute surgical opening in the scrotum, no incision with a knife is made into the vas, but only a simple puncture with a fine-pointed trocar carrying its cannula within, which Luys found preferable to a needle on the ground that it is less traumatizing to the mucosa. The puncture is made exactly like an intravenous injection. (See Fig. 37.) This is the delicate point in his procedure, for the thick wall of the vas is much more difficult to pierce than the soft wall of a vein, and the wide lumen of the vein is not comparable to the extremely narrow and fine lumen of the vas. Several attempts may be necessary before the trocar finds the lumen. The trocar is now removed, a syringe attached to the cannula, and the injection made as in other technics. The cannula is withdrawn, the vas replaced in the fibrous tunica, the latter closed with a bundle of Florence horsehairs inserted as a drain, after which it only remains to suture the skin with 3 horsehairs.

Indications for vas puncture. These have been formulated by Cumming and Glenn as follows: (1) cases with persisting or recurring epididymitis, with chronic seminal vesiculitis, which have resisted other treatment; (2) cases with acute vesiculitis, especially if there is a beginning arthritis; (3) cases with chronic vesicular involvement, with coexisting arthritis; (4) optional cases having recurring urethritis but no palpable evidence of vesiculitis, and no evidence of a focus within the urethra; (5) cases with recurrent urethritis, without a focus within the urethra, and chronic prostatitis and seminal vesiculitis.

Vas puncture is contraindicated in: (1) cases with acute epididymitis; (2) cases with acute anterior urethritis.

It was the experience of these writers, after an intensive study of 55 cases at the Walter Reed U. S. Army General Hospital, that vas puncture, with one or more injections of a solution of collargol or other suitable medication, produced improvement or cure in a large number of cases, especially where the disease was confined to the prostate and vesicles. They also found gonorrheal arthritis amenable to this treatment, with eradication of the focus of infection and immediate abatement of arthritis, as indicated by striking results in some of the cases reported.

In the technic of these authors, an incision one-half inch long is made on the anterior surface of the scrotum; the vas is then isolated and bared for at least one inch, the covering structures being stripped in a longitudinal direction along the axis of the cord. With a piece of tape or gauze held under the vas for traction and elevation, it is possible to hold it completely taut and thus facilitate the introduction of the needle. While vas puncture does not guarantee a certain cure, it rendered more than 50 per cent. of the patients symptom-free in the series reported.

VASOLIGATURE

The procedure of interrupting the continuity of the vas, variously known as *vasoligature*, *vasectomy*, and *division of the vas*, is utilized for the purpose of shutting off infection that might travel through the vas or its sheath, either from the epididymis and testis to the seminal vesicle or, vice versa, from the prostatic bed (after prostatectomy) and seminal vesicle to the epididymis and testis.

In a certain percentage of prostatic cases, characterized by hypertrophy and obstructive phenomena, bilateral section of the vas has a definite influence in the direction of promoting decongestion of the prostate, putting the latter at rest, minimizing the prostatic and urinary symptoms, and preventing the common complication of epididymitis that has been so frequently observed. Thus, Crabtree and Brodny collected 1624 reported cases of prostatectomy carried out without previous vasoligation or vasectomy, in 21.6 per cent. of which epididymitis followed; against these they place 514 cases in which vasectomy was performed in connection with the prostatectomy, with a yield of only 8 cases of epididymitis, or a percentage of 1.5.

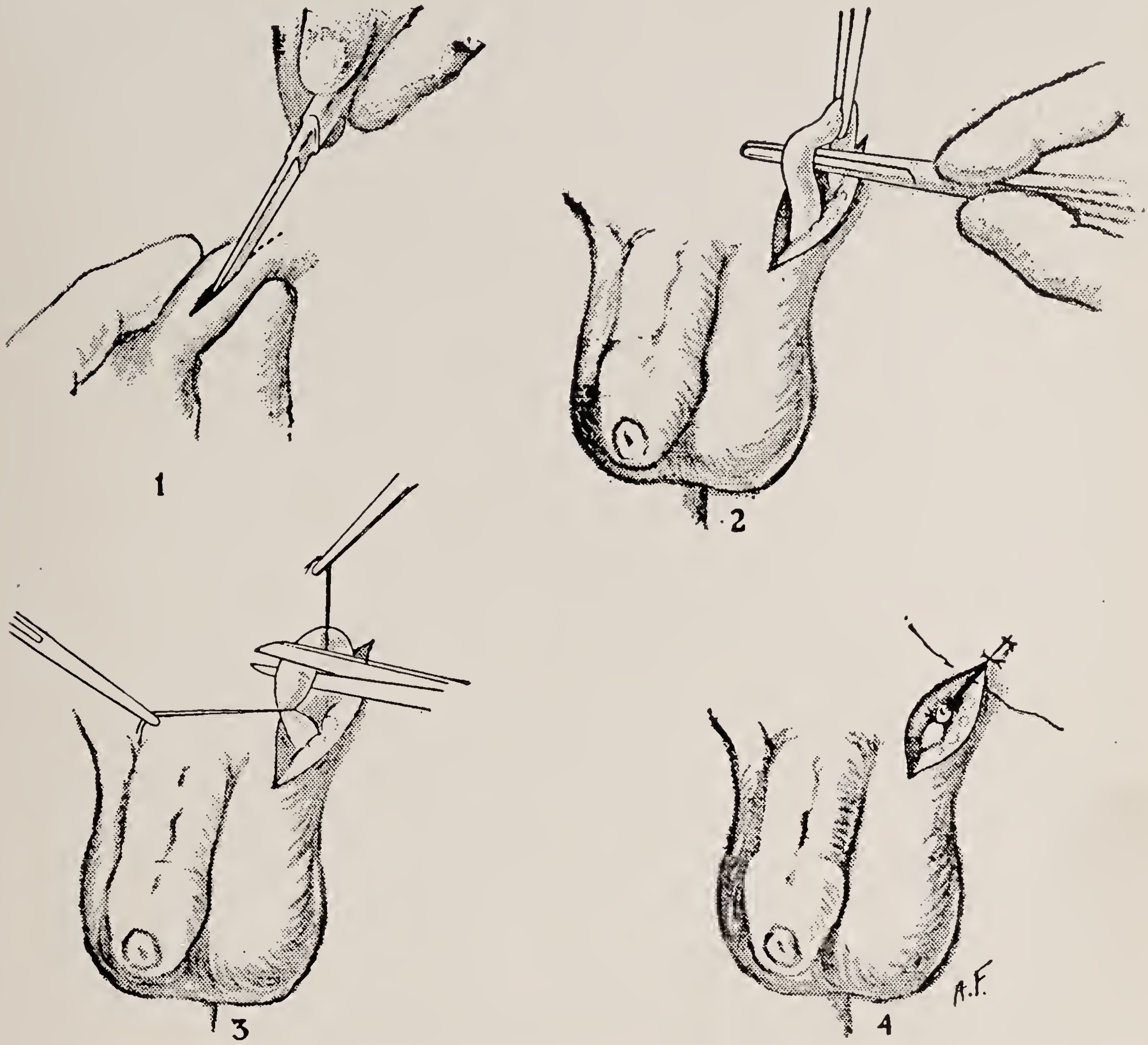


FIG. 38. Drawing to illustrate the different steps in the technic of vasoligature, previous to prostatectomy, with a view to preventing the common complication of epididymitis after prostatectomy.

1. The vas is grasped firmly between the thumb and index finger at the level of the scrotum, and a skin incision made.

2. The vas is separated from the vascular elements of the cord, drawn out through the incision and held with forceps.

3. The vas is ligated in two places and cut between the ligatures.

4. The stumps of the vas are dropped back into the scrotum and the incision closed with interrupted sutures, without drainage.

Bilateral vasoligature for tuberculosis of the vas deferens and epididymis is also sometimes indicated and can best be accomplished by use of this open surgical method. (See text.)

It is worthy of note that the indication for this procedure arises at a time in the individual's life when there is no longer a question of procreation and when the chief aim is to relieve him from the irksome symptoms of prostatic hypertrophy and urinary retention. Incidentally, however, the procedure has a beneficial effect on the symptoms of vesiculitis that may be present at any age, by diminishing the compression and deviation of the ejaculatory ducts. Minet observed that the setting at rest of the ampulla acted rather notably in the direction of cure of the vesiculitis. Keyes, too, was inclined to support this view. Parker regarded vasectomy as a useful means of preventing prostatic hypertrophy due to cessation of the sexual function. During the nineteenth century many attempts were made to overcome prostatic hypertrophy by vasoligation and castration. Among the names associated with such work are those of Cowper, Gösselin, Curling, Lennander, Pasteau, Pousson, Albarran, Guyon and others, but it was not demonstrated clinically that such a result could be obtained by this means.

That vasoligation might have a vasoconstrictor and decongestive effect upon the hypertrophied prostate could readily be admitted, and also that this might result in an improvement of urinary symptoms. We know, for example, that in adenomatous hypertrophy of the prostate, when cystostomy is done to derivate the urine and put the prostate at rest, the much enlarged adenomatous organ, together with the associated periprostatitis, is notably reduced in size. But that simple division of the vas can have any effect upon the adenoma itself has never been established.

In the light, however, of our increasing knowledge of the hormonal relationships within the male organism, and of the modern conception of an endocrine interaction between testis and prostate, the possibility that vasoligature may reduce the benign hypertrophy of the latter organ seems less fantastic. The recent report of Huggins and his coworkers on the relief afforded by castration in cases of advanced carcinoma of the prostate suggests that the claims of the earlier writers may not have been without foundation when they reported that vasoligature and castration relieved symptoms in benign adenomatous hypertrophy of the prostate. It appears that there is room for further research in this field.

Technic of vasoligature. After the usual preparation of the scrotum, and under either local or general anesthesia, an incision 2 to 4 cm. long is made in the skin and fascial sheaths of the scrotum directly above the spermatic cord and parallel to it, close to the root of the penis, where it can easily be palpated. The scrotum is firmly grasped between the thumb and index finger in order to furnish a plane of adequate resistance for the incision. As soon as the cord is exposed it is picked up with forceps and the vas isolated; the artery, veins, and nerves are then carefully dissected away from the vas, which is entirely denuded from its sheath for a distance of about 3 cm. and brought out of the wound. (See Fig. 38.) The vas is then clamped, a ligature placed at each end, and a portion of the vas about 2 cm. in length resected between them. The proximal stump of the vas is dropped back into the scrotum and the distal stump brought to the upper end of the wound, where it is sutured to the tunica vaginalis in order to maintain the testis suspended in its proper position. The wound is then closed with a chromic catgut suture as in any other operation of this region. A suspensory is applied to immobilize the scrotum and hold the dressing in position; the patient is then kept in bed for 3 or 4 days, or as long as necessary.

Other technics for the ligation of the vas have been described, in which special clamps, forceps, and needles are used to accomplish the ligature at the scrotum without making an opening, such, for example, as the method described by Alyea, Colston and others. (See Fig. 39.) The open method, however, is to be preferred as the most rational, the most efficient, and the most truly surgical in its execution.

Technic of simple division of the vas (Morson's method). In Morson's procedure, instead of ligating the vas, these ducts are cut across and the ends crushed between artery forceps. In the event of its being considered desirable to inject some sclerosing or antiseptic substance to prevent a subsequent vesiculitis, the proximal end of each vas is first held open while the injection is made, and it is not crushed until after this has been done. A blunt hypodermic needle, to which a glass syringe is attached, is passed down the proximal lumen of the duct, and 4 cc. of 1:10 carbolic acid or other sclerosing or antiseptic substance injected, after which the lumen is crushed like the distal one. The two ends of the vas are now pushed back into the scrotum and the skin wound sutured with catgut.

Simplified vasectomy procedure (Darget and Labot's method). Instead of exposing the vasa by an incision on each side of the scrotum, these authors have made use of a single median incision

4 to 5 cm. long drawn vertically downward upon the raphe from a point about one finger's breadth below the junction of the penis and the scrotum, permitting a completely avascular approach to each side of the scrotum. Each spermatic cord can thus be exposed by traversing the median septum. The vas is isolated from the elements of the cord, ligated with a double ligature, and sectioned, allowing both of the vas stumps to drop back into the scrotum.

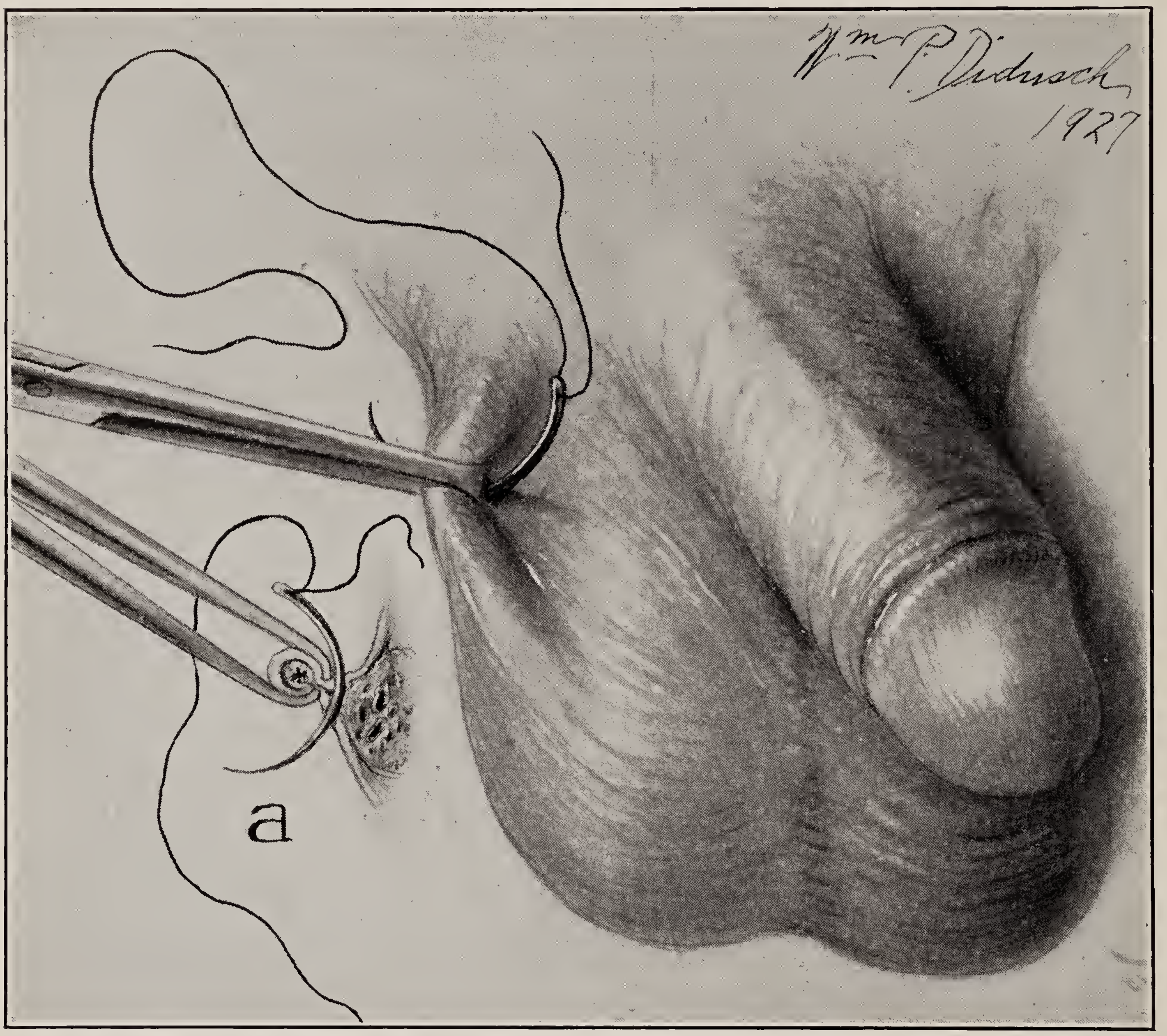


Fig. 39. Vasoligation without a skin incision (Alyea's method). (Courtesy of J. A. C. Colston, Journal of the American Medical Association, p. 526, 1928.)

The operation is an office procedure and can be done under local anesthesia. The cords are first anesthetized in the right and left groins respectively, after which skin anesthesia is obtained by an injection upon the raphe at the level of the upper part of the scrotum.

OPERATIONS FOR TUBERCULOSIS OF THE VASA DEFERENTIA

Bilateral vasoligature. In cases where the prostate and one or both seminal vesicles have been discovered to be tuberculous, there should be no hesitation in ligating both vasa in order to limit the further spread of the tuberculous infection into the epididymes and testes. The impossibility of entirely overcoming the infection residing in the prostatic bed, even after removal of the prostate itself, makes the division of both vasa an essential part of the operative technic in prostatectomy, in order to safeguard the testes from subsequent attacks of orchitis. (See Fig. 38.)

Legueu holds that in the presence of bilateral disease of the seminal vesicles the second vas should systematically be ligated in the course of even a unilateral operation, in order to avoid infection of a healthy testis. Lapeyre and Israel have shown the good results to vesicles and prostate following double section of the vasa. Lapeyre makes it a practice to resect the healthy vas in a case of unilateral involvement. Barney points out that the patient with genital tuberculosis is already sterile, so that it is not a question of conserving or destroying generative function.

The possible formation of a fistula at the site of the severed vas has been handled by Cunningham by injecting the stump with crude carbolic acid. He considers that any immediate discomfort that may follow (and often there is none) is not to be weighed against the importance of exterminating so severe a disease.

Epididymovasectomy. When the epididymis is affected with tuberculosis, the indication is absolute for its surgical removal, together with the vas of the affected side. Opinions differ as to the advisability of prolonging the operation upward and including a vesiculectomy such as Marion, Duval, Young, and others advocate. The technic of epididymovasectomy involves a skin incision from scrotum to groin, isolation of the vas from the other elements of the cord, and its dissection up to the inguinal canal. It is tied as high up as possible, then clamped and severed with the thermocautery; the abdominal end is left free in the abdominal cavity, after which an epididymectomy is carried out, by a technic which does not come within the scope of this writer's paper.

Epididymovasectomy with vas transplantation (Cabot and Barney's technic). A special technic for a combined epididymovasectomy has been described by these two authors, in which the vas is drawn up through the inguinal ring and out through an incision in the abdominal wall, as follows: After removal of the epididymis

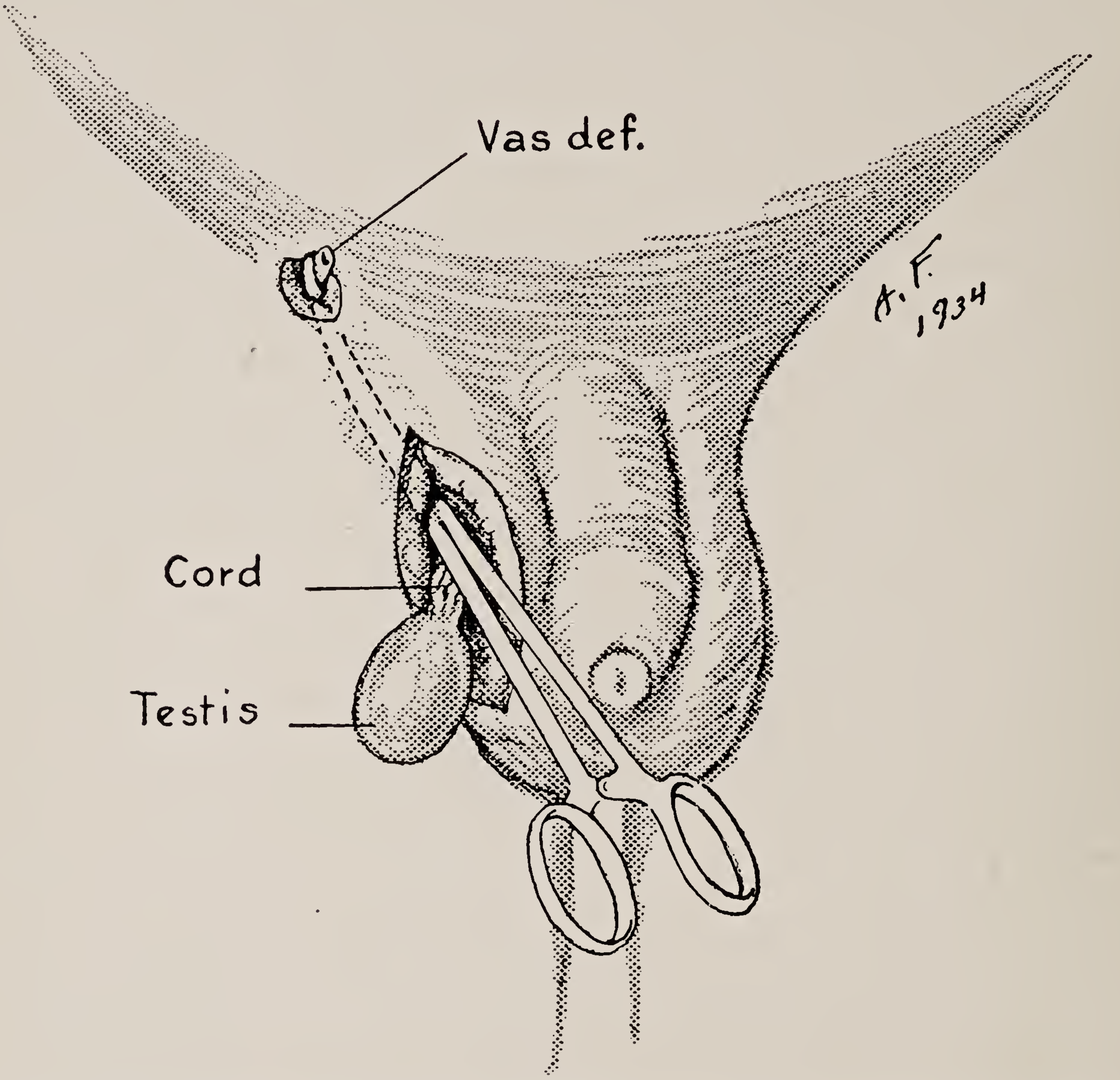


Fig. 40. Illustrating the method of epididymovasectomy with vas transplantation and fixation to the skin of the abdomen, in cases of tuberculosis of the lower spermatic tract. The method offers the advantage that after removal of the tuberculous epididymis the scrotal wound may heal by primary union without contamination from the secretion of the vas. It also allows the tuberculous vasa and vesicles to discharge their infected contents, and at the same time makes it possible to irrigate them with a strong antiseptic solution. (See text.)

by the usual technic, together with an inch or two of the vas, the remainder of the vas is freed from the spermatic cord by blunt dissection with the fingers up to the external inguinal ring. (See Fig. 40.) Guided by the finger, the clamp on the lower end of the vas is passed up to the external ring and carefully inserted in the canal, with care not to push it between the fascia and the fat in front of the canal. It is then pushed through the canal, in an upward and outward direction, until the tip lies directly beneath the fascia at approximately the level of the internal inguinal ring. An incision not over one-half inch long is made over the tip of the clamp, and the latter, carrying the vas with it, is pushed out through the opening. The rest of the vas, freed as far as the finger can reach, is now pulled out by steady traction, and a right-angled clamp applied at its lowest accessible point. It is then divided, cauterized with phenol, and dropped back, the wound in the groin being closed with a suitable suture. A small cigaret drain is placed at the lower angle of the scrotal wound and, after replacing the testis in its normal position, this wound is closed with interrupted stitches of crine or chromic catgut. As a rule, both wounds heal by primary union and the formation of a fistula is prevented.

Young used at one time a similar technic but anchored the end of the vas in the abdominal wound for purposes of drainage and injection. We have already seen, however, in our study of surgical procedures upon the seminal vesicles, that Young at a later time came to advocate a radical operation involving excision of the entire spermatic tract from prostate to epididymis for tuberculosis of any part of the tract.

Ligation and section of the cord, with castration. When, for any reason, the testis itself is to be removed (as for tuberculosis, syphilis, tumors, torsion, or severe injury), the vas is brought out and isolated as before, and held up by a grooved sound inserted between it and the other elements of the cord; the latter are then exposed, one by one, and ligated and cut, the vas alone remaining attached to the testis. This is drawn somewhat farther out through the orifice in the skin, and tied 3 or 4 cm. higher up than were the vessels. After being cut it is treated with the thermocautery and allowed to draw up within the proximal stump of the cord. Sometimes it is wise to anchor the stump of the cord by a transfixion suture to the transversalis muscle and fascia about one inch from the external inguinal ring.

OPERATIONS UPON THE AMPULLÆ

Surgical interventions upon the ampulla alone are rarely performed, because in very few instances will the ampulla itself reveal pathology that does not also involve the vesicle or the vas deferens proper.

Ampullotomy. The surgical drainage of the ampulla by either the perineal or the inguinosuprapubic route finds its correct indication in those cases of acute or chronic ampullitis where the ampullæ are dilated and inflamed, and in which the multiple crypts and sacculations cannot be emptied in any other way. The operation is carried out by the same perineal incision and exposure as are employed for vesiculectomy. (See Figs. 28, 29, 30, 31 and 32.) One or several incisions are then made in each ampulla for the purpose of draining the irregular cavities, which may be found full of pus and concretions. Drainage is provided by a small, soft rubber urethral catheter attached to the border of the ampullar incision by means of a chromic catgut suture, leaving a small cigaret drain at the base of the prostate. The wound is then closed in the same way as in vesiculectomy.

Ampullectomy. Operations for the removal of the ampulla are more commonly indicated than has been suspected, particularly in tuberculosis or in anomalies of the tract. We have seen in the chapter on Anomalies that an ectopic ureter sometimes opens into the ampulla; here an ampullo-ureteronephrectomy may be indicated, in view of the fact that the kidney and ureter have lost their entire function.

The ampulla may be chronically diseased with hydatid infestation or tuberculosis, and in such cases ampullectomy is properly indicated. The technic for the anatomical exposure of the ampulla is the same as that used for vesiculectomy. (See Figs. 30, 31 and 32.) The ampulla is ligated as high up as possible. We have already seen that in tuberculous infection the vesicle and ampulla are both nearly always involved, owing to their intimate anatomophysiological relationship; hence the removal of the ampulla of one side almost invariably means the removal of the vesicle of the same side.

Ampullovesiculectomy. In tuberculosis of the spermatic tract, when the lesion is primarily found in the seminal vesicles and ampullæ, the removal of the entire upper spermatic tract is indicated. Essentially, ampullovesiculectomy consists in placing two ligatures, one at the base of the prostate, where the ampulla and vesicle unite to enter the prostate by a common duct, and the other as high up as possible in the ampulla, at the level of the place where the ampulla crosses the ureter. The procedure may be unilateral or bilateral. If bilateral, sterility is to be expected. The approach is made as in simple vesiculectomy.

Ampullovasectomy. In certain cases in which the vesicle or epididymis has already been removed, the ampulla and the stump of the vas may become diseased or fistulous, and call for an ampullovasectomy procedure. This may be accomplished by the perineal or inguinal route of approach, or by a combination of the two methods.

II. OPERATIONS FOR THE CORRECTION OF STERILITY

A number of operations for the correction of sterility have been described in the literature. They may be divided into two main groups: (1) operations for anastomosis between the vas and epididymis, (2) operations for anastomosis between the vas and testis.

In addition to these, there have been described also the anastomosis of the vas deferens to a spermatocele, and the anastomosis of one vas to the testis or the epididymis of the opposite side.

The aim in all these cases is to create a new avenue for the passage of spermatozoa from the testis to the upper spermatic tract, or, in other words, to overcome the mechanical factors producing azoospermia in these patients. The two principal methods are:

(1) Laterolateral anastomosis
(2) Terminoterminal anastomosis

Laterolateral vasoepididymostomy (**Martin's operation**). The principle involved in this and the following procedures is the anastomosis of that part of the spermatic tract lying above an obstructed epididymis into that part of the tract lying below the obstruction. The first attempt of this kind was made by Martin and his coworkers in 1902. The original Martin operation was extravaginal and consisted of a laterolateral anastomosis of the vas into the head of the epididymis. This was because, in the given case, the tail of the epididymis of the individual in question showed no milky fluid or spermatozoa, whereas these were present in the head. The vas was incised for one-fourth of an inch at the level of the top of the testis. The epididymis was then approached from the outer side and its entire length exposed. The head of the latter having been chosen for the anastomosis, a portion was excised, and the wound of the vas implanted into it by 4 silver wire sutures, carried on small-faced needles from the outer surface of the vas into its lumen, and thence, from the cut surface of the opening made in the epididymis, through its fibrous tunic. A suture was placed at either end of the vas incision and the latter held open by two other sutures. The skin incision was closed with a catgut suture. (See Fig. 41.)

Since Martin's time a number of modifications have been made by different authors, among whom the names of Fuller, McKenna, Hagner, Quinby, Bogoljuboff and others are found. The materials of suture include silk, human hair, and silver wire, as well as catgut, and the choice of the point of attachment to the epididymis varies with the author.

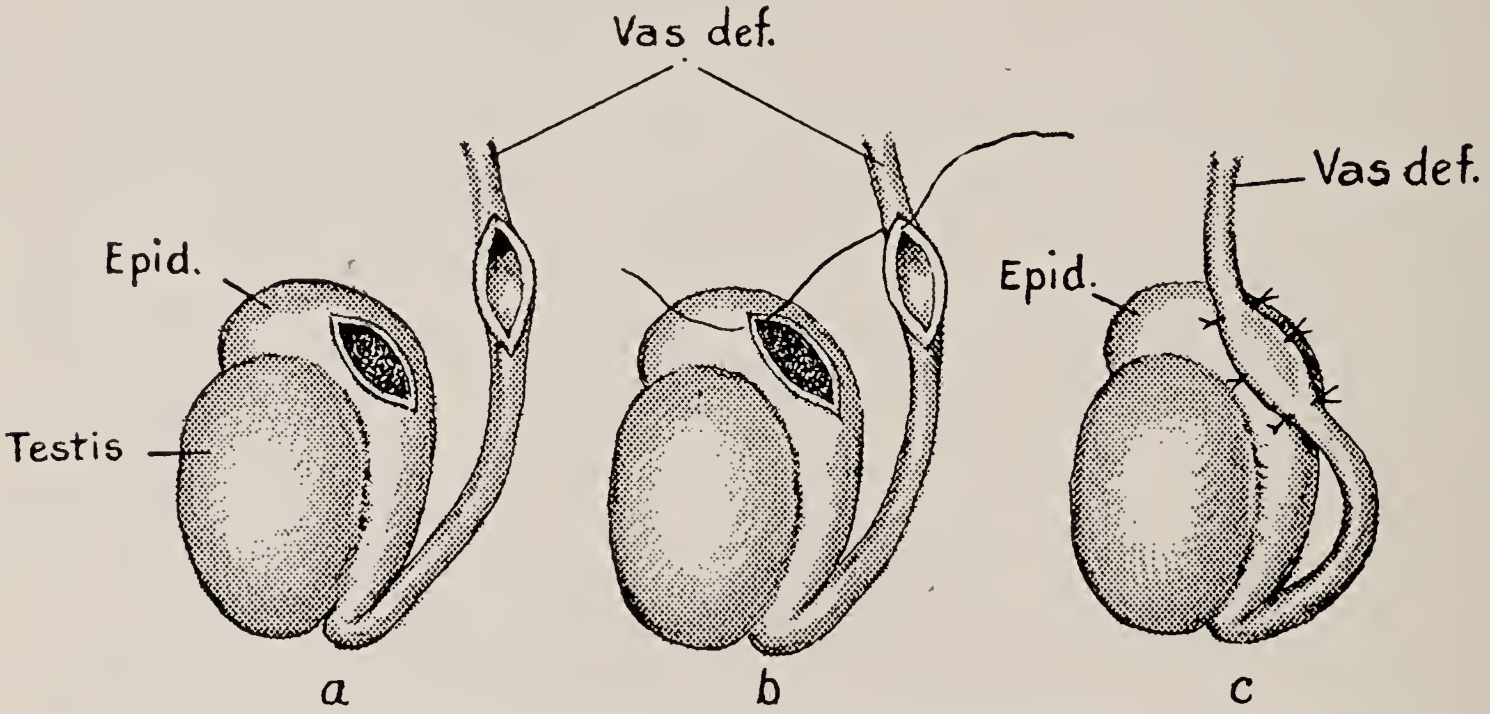


FIG. 41. Technic of vasoepididymostomy for the correction of sterility due to obstruction of the vas.

A. A longitudinal incision is made in the epididymis at the level of the globus major, and a similar incision in the vas deferens above the point of obstruction.

B. After ascertaining the patency of the vas and the presence of living spermatozoa in the epididymal substance, a laterolateral anastomosis is made.

C. The anatomosis of the vas to the head of the epididymis is secured by interrupted sutures of silver wire or other suitable material. (See text.)

Epididymovasostomy (McKenna's procedure). In 1915 McKenna described an improvement over the Martin procedure, which he called a " short circuit of the vas deferens." It was designed for cases in which an old gonorrheal epididymitis has resulted in an obstruction of the vas between the tail of the epididymis and the external inguinal ring. The first step is to determine the patency of the upper portion of the vas by injection; if it should prove to be occluded the operation is useless and should not be pushed further. The vas and epididymis are exposed by an oblique inguinal incision, as for hernia. The vas is carefully disengaged from the spermatic vessels for a length of 4 cm. and an incision one-half inch long made into its lumen. The incision into the epididymis is made about 2½ inches above the head of the latter. By means of a long hypodermic needle a silkworm gut is introduced into the lumen of the vas through the incision already made, and is pushed into the lumen of the cord above the incision; the point of the needle is then brought out through the wall about 2 inches above the lower opening. The thread is drawn through the needle at this point and the needle withdrawn through the lumen of the vas, thus leaving the silkworm gut extending from the incision below and out through the wall 2 inches above, both its ends being free. A laterolateral anastomosis of the vas and epididymis is then made with 2 sutures of chromicized catgut, which are tied for permanent fixation. After closure of the wound in the scrotum, the ends of the silkworm gut are tied over the scrotal skin to prevent clots from organizing and closing the point of anastomosis. The silkworm gut is removed after 7 to 10 days.

Lespinasse's modification: "direct vasoepididymostomy." In 1918 Lespinasse suggested that in the existing methods of anastomosis a considerable distance had to be bridged by epithelium between the functional end of the epididymal tube and the vas; he observed that this bridge often fails to develop, and that consequently the operation itself is a failure. The two chief causes were, in his opinion, overgrowth of connective tissue and organization of blood clots. To obviate this difficulty, he devised a method that he called "direct vasoepididymostomy." This consisted in the selection of a single tubule in the epididymis, just above the obstruction, to be anastomosed into the vas. A No. 00000 silk is threaded into a No. 19 bayonet-pointed needle and passed through the wall of this tubule (which should have the same direction as the long axis of the body of the epididymis), down its lumen, and out again at a point 2 to 4 mm. below that of its entrance. The respective ends of this "crown" suture are passed into the vas, one in each longitudinal direction; they pass through its lumen and are brought out again a few millimeters away, transfixing the wall of the vas; when traction is exerted on the ends, it will draw the epididymal tubule into the orifice in the vas. Two stitches fix the vas to the capsule of the epididymis to carry the weight of the testis, while two others, of very fine catgut, hold open the longitudinal slit in the vas; the last two include only the wall of the vas and do not enter its lumen.

Hagner's modification. Hagner opens the tunica vaginalis and exposes the entire epididymis, since from this approach it is easier to pick out the portion of the globus major richest in tubules, thus facilitating the discovery of that portion that may contain live spermatozoa. He determines the patency of the vas by a very fine tear-duct probe, believing that injection of fluid may have the effect of a foreign substance in causing cicatrization away from the field of operation. In an unobstructed vas the probe can pass for a distance of 16 to 20 cm. If, on rectal palpation, there is no evidence of infiltration of the ampulla, one can be reasonably sure that the vas is patent. From a suitable-looking place in the epididymis an elliptical piece is excised. Escape of a milky fluid is a sign that live spermatozoa are probably present. The fluid is examined, and if these are found, laterolateral anastomosis is made with very fine silver wire. (See Fig. 42.) It is important not to cut too deeply into the lumen of the vas for fear one may go through the entire diameter of the tube; nor must one strip the vas too closely. The first suture is placed at the distal end of the incision in the vas, taking a good strong bite, as this is the anchoring suture for the operation, and the obstruction is below this point. The suture is then anchored firmly in the lower end of the elliptical incision of the epididymis. Two lateral sutures are placed to take a fairly heavy bite in the epididymis and include some of the cut tubules. If only the fibrous covering of the epididymis is taken up in the suture, the cut tubules drop back when the anastomosis is made. The suture is next passed through the cut edges of the vas, taking just enough tissue to approximate the edges. The last suture is then passed in the same way through the upper end of the incision in the epididymis. It is then passed through the vas at the upper angle of the incision, being carefully placed so as not to occlude the lumen. This is tested out with a tear-duct probe. The anastomosis is then complete. If the vas is beaded, the operation is useless, for this nearly always indicates occlusion.

Hagner has found that a failure on the first occasion to overcome sterility need not discourage one from a second attempt, when live spermatozoa are present. He waits a year, however, before operating a second time, as he has had successes that did not manifest themselves until 8 or 9 months had elapsed after operation. He had cures in 19 of the 31 cases operated on (61.3 per cent.).

Anastomosis of vas to a spermatocele. In view of the relative frequency with which spermatoceles are found, it is not unusual for one to be present in a case of occlusion of the epididymis. When such is the case, it is convenient to make a lateral anastomosis between the vas and the spermatocele, or, if preferred, an implantation of the cut end of the vas may be made into the latter. (See Fig. 42.) Hagner reported a successful anastomosis of this kind, in which within 6 weeks after the operation the patient had live spermatozoa, and his wife gave birth to a child within a year.

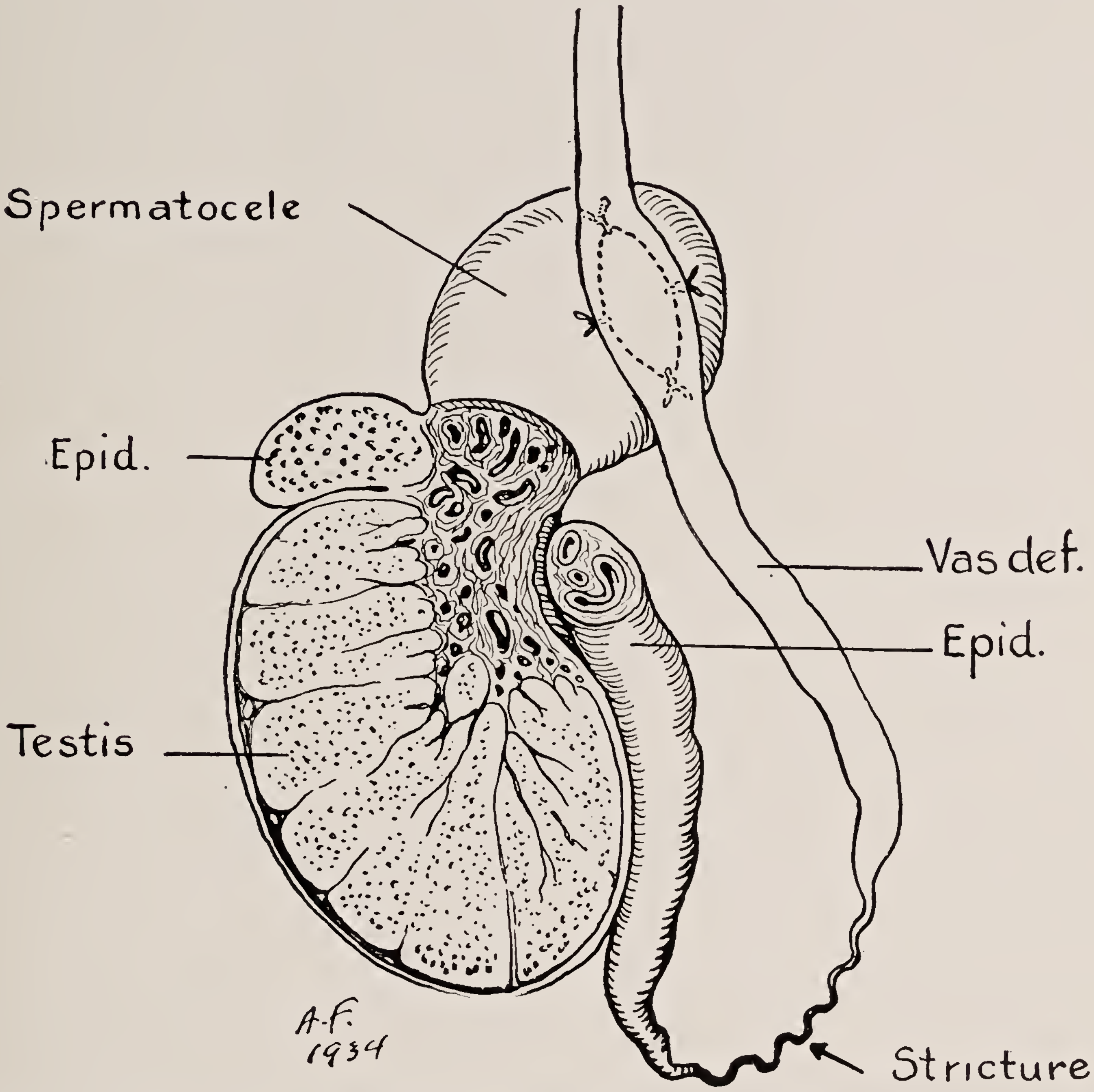


FIG. 42. Drawing to illustrate the laterolateral anastomosis of the vas deferens to a spermatocele. (Hagner's method.)

Crossed anastomosis of vas. Another type of anastomosis reported by Hagner is that of leading the vas across through the septum of the scrotum to the epididymis of the other side. (See Fig. 43.) He did this in 3 cases in which the epididymis of one side contained actively motile spermatozoa, but the corresponding vas was occluded, being only a fibrous cord; while on the other side the vas was patent, but there were no spermatozoa to be found in its epididymis. The patent vas was therefore anastomosed into the fertile epididymis.

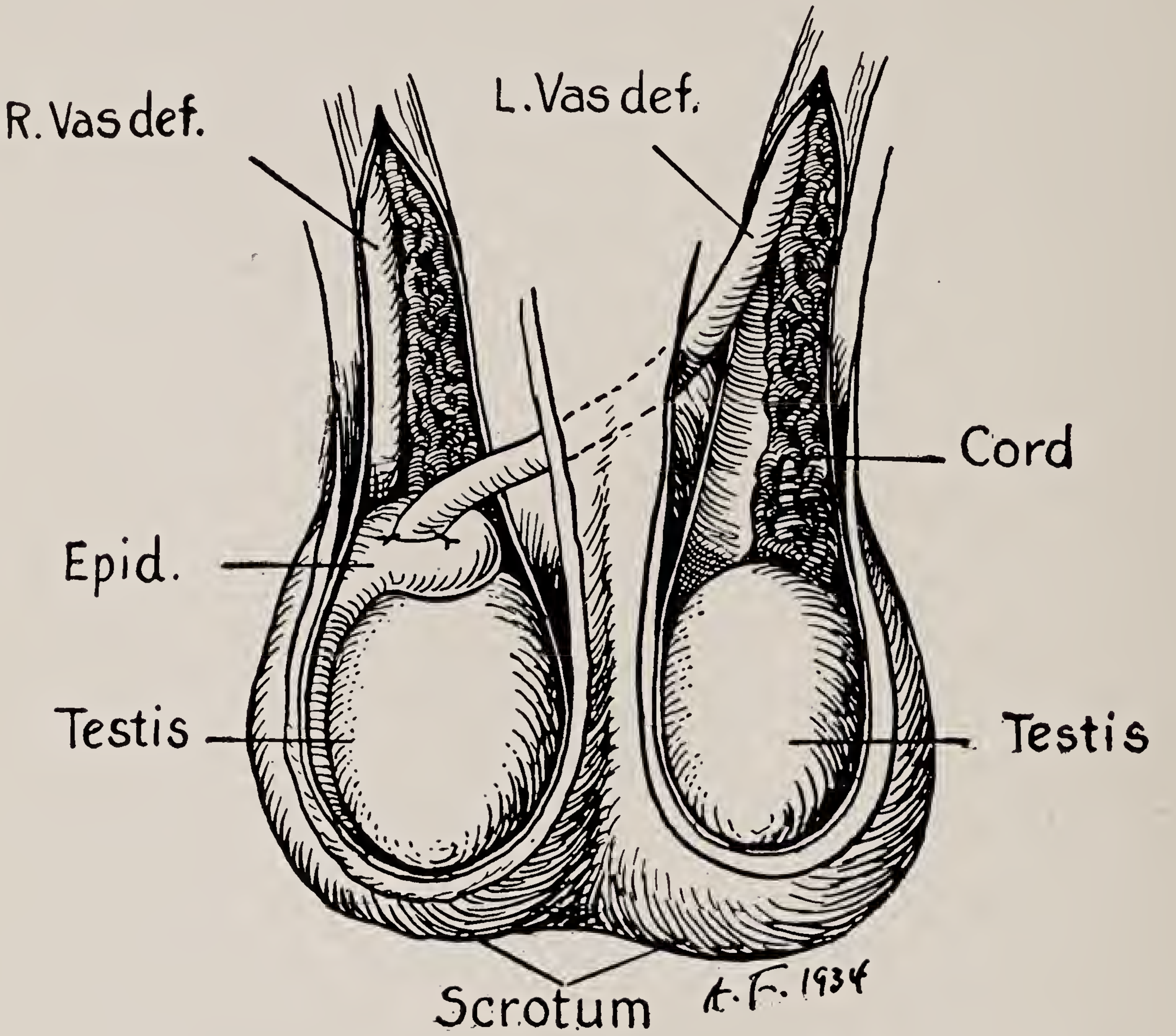


FIG. 43. Crossed anastomosis of vas. When the epididymis of one side has been removed or contains no living spermatozoa, and the vas of the other side is obstructed, it is possible to make a crossed anastomosis of the healthy vas through the median septum to the epididymis of the opposite side for the correction of sterility, as Hagner has shown.

Partial epididymectomy with terminoterminal anastomosis of vas. Watson and Cunningham have described a procedure in which, after removal of the tail of the epididymis, the upper portion of the latter organ is tunneled for reception of the vas. The split end of the vas is then carried into this tunnel, where it is invaginated by a terminoterminal anastomosis, with 2 sutures placed one at the external and one at the internal point of union, as may be seen in Figure 44.

Results of vasoepididymostomy procedures. Relatively few of these anastomotic procedures have been successful. Several reasons may be found for failure.

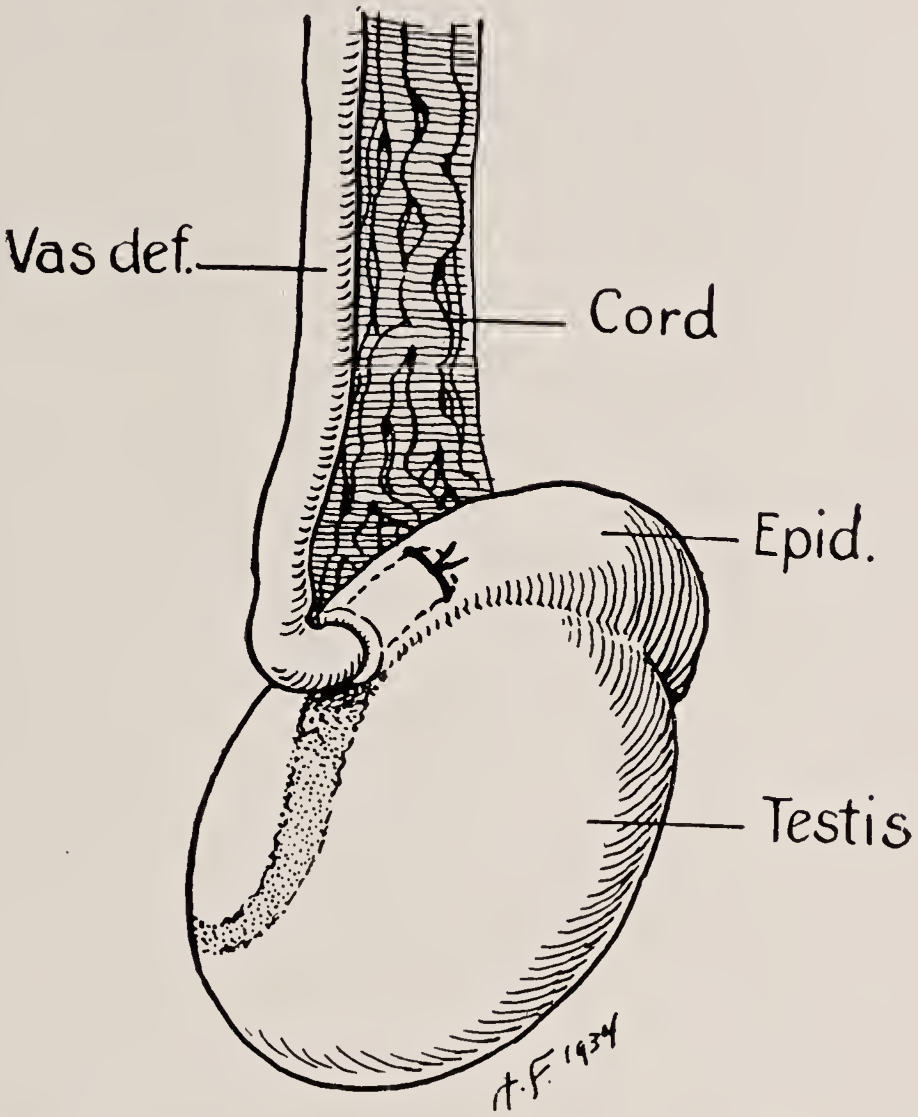


FIG. 44. Partial epididymectomy with terminoterminal anastomosis of vas to epididymis, by invagination of the end of the vas into a tunnel constructed for its reception in the globus major or body of the epididymis. This invagination is held in place by 2 transfixed sutures.

(1) The extremely minute size of the lumen of the vas at the point of anastomosis.

(2) The fact that even slight hemorrhage at the point of anastomosis, as well as the irritation caused by the suture material, may result in formation of scar tissue sufficient to occlude the channel.

(3) The friability of the epididymal tubule, rendering it liable to rupture during operation.

(4) The tension at the point of anastomosis, which is increased with every movement of the bladder or testis.

(5) The liability of an infection in the field of the operation, which may not only tear apart the anastomosis but may also invite other complications, such as hematoma or epididymo-orchitis.

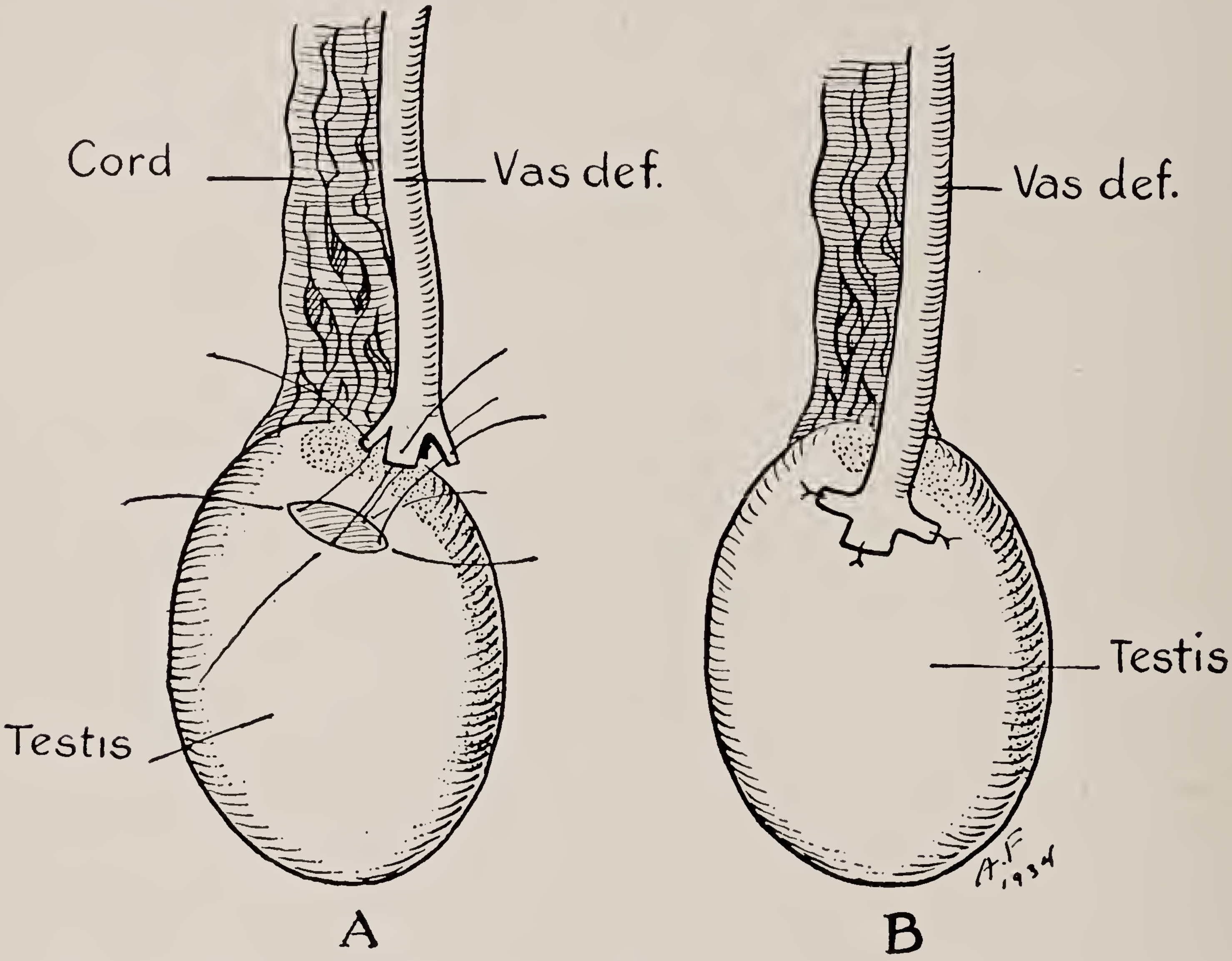


Fig. 45. Vaso-orchidostomy following epididymectomy. The diseased epididymis has been removed and the vas deferens is transplanted into the testicular substance.

A. An incision is made into the testis, penetrating Highmore's body, to receive the end of the vas, which has been cut into 4 small flaps for the anastomosis.
B. The flaps are attached to the edge of the tunica albuginea by means of separate sutures, thus accomplishing a terminoterminal anastomosis.

Vasotesticular implantation. Anastomosis of the vas to Highmore's body was tried by Bardenheuer, Sanfelice (1888), Griffini (1887), Fabrini (1901), and by Scaduto, in animals, and by Rasumowsky in humans, but without striking success. Two types of operation may be performed: (1) transplantation of the vas into the uppermost part of the testis after removal of a diseased epididymis, and (2) implantation of the vas into any part of the testis that seems most available, without disturbing the epididymis. The technic for these procedures follows the same rules as those for any other conservative operation upon the testis and epididymis.

Type 1. Vaso-orchidostomy following epididymectomy. The vaginalis is opened as in the preceding operations, and the vas exposed and sectioned 1 cm. from the tail of the epididymis. The latter organ, being diseased, is then totally removed by an epididymectomy. (See Fig. 45.) The testis is opened on its posterosuperior border, slightly nearer to the internal than to the external aspect and nearer to the anterior than to the posterior extremity,

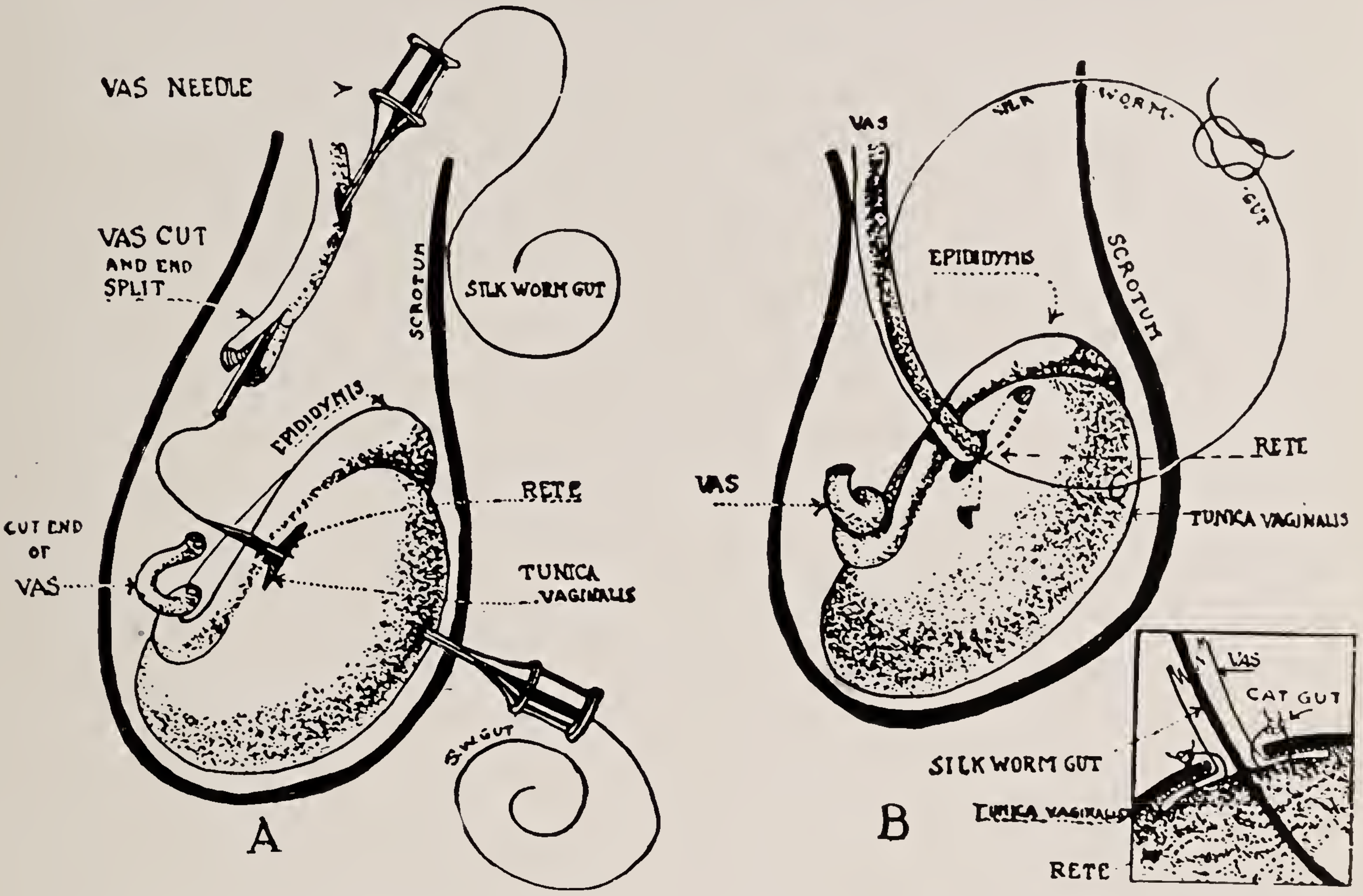


FIG. 46. Vasotesticular implantation, or anastomosis of the vas into the rete testis (Rolnick's operation).

A. The vas is cut from its attachment to the tail of the epididymis and transplanted into an incision in the rete testis. Silkworm gut is passed through two hypodermic needles, one of which passes from the opposite side of the testis and out through the incision, while the other is similarly passed through the vas from a point a little above the cut end and out through the latter.

B. The anastomosis is accomplished by drawing the end of the vas into the rete testis and anchoring it to the tunica albuginea by two flaps, after which the ends of the silkworm gut are passed out through the tunica vaginalis and scrotum, and united above the skin. (Courtesy of H. C. Rolnick, Surgery, Gynecology and Obstetrics, p. 559, 1927.)

the incision penetrating Highmore's body. The end of the vas is now split into four parts by two vertical slits transecting one another, making four tips ready for anastomosis. These are now implanted into the rete testis at the place already prepared by incision. After this invagination or anastomosis of the vas, the two lips of the tunica albuginea are sutured with a few separate stitches to anchor the vas and reinforce its implantation, after which the testis is replaced within the scrotum and the wound closed in the usual manner, leaving a small cigaret drain at its lowermost angle.

Type 2. Anastomosis of the vas to the rete testis (Rolnick's operation). The fact that the rete testis consists of many tubules makes it theoretically easier to form an anastomosis here than in the epididymis with its single tube. The main feature of Rolnick's procedure is that in uniting the vas to the rete a silkworm gut is added, just as is done in McKenna's operation on the epididymis. The purpose of the gut is to develop a channel with a view to preventing the organization of a scar and also to make a path for the process of epithelization to follow. In addition the silkworm serves to fix the testis and vas quite satisfactorily, thus preventing tension at the point of anastomosis. A comparison of the results from this method with those that followed a similar series of experiments with the vas and epididymis shows the testis to be more resistant to infection than the epididymis, and that it tolerates considerable trauma.

The vas is lifted out of its sheath about 1½ inches above the site of Highmore's body, and a small longitudinal incision made in it. After its patency has been determined, a blunt vasotomy needle is inserted downward toward the epididymis through the opening in the vas (see Fig. 46); the latter is then divided over the needle at the point where it crosses Highmore's body. The upper end of the vas is split into two or three parts and 000 catgut sutures inserted through these split ends with a No. 23-gauge hypodermic needle. For the fine blood vessel and vas anastomoses all the suturing is done with hypodermic needles, as suggested by Belfield. The silkworm sutures are passed through the testis and the vas, the split ends of the vas being thus united to the tunica of the testis after dipping somewhat into the rete. As in McKenna's procedure, the silkworm is carried out onto the skin on both sides and there tied, after which it is left 7 to 10 days before removal.

Surgical sterilization by vasoligature: the Steinach operation. We have already alluded to vasoligature as a preliminary procedure in preparation for prostatectomy for the purpose of preventing the annoying complications of epididymitis. The surgical procedure advocated by Steinach for sterilization is identical in its technic with the method already described (see Fig. 38), but is done for a widely different purpose. In 1912 Steinach published an account of his experiments in vasoligature as a means of encouraging active proliferation of the interstitial cells of the testis. He claimed that by obliterating the generative cells of the organ, a compensatory activity is brought about in the interstitial portion of the gland, which elaborates the male hormone, and that the operation serves, therefore, to exalt sexual potency and to promote rejuvenation of the individual.

This theory has been subjected to much criticism in the medical literature, and in the opinion of many its truth has not been fully established.

CHAPTER XII

SURGICAL LESIONS OF THE SPERMATIC CORD

INTRODUCTION

In the preceding chapters we have discussed surgical lesions of the upper spermatic tract alone, including in this group, because of its anatomical relations, the vas deferens down to its point of emergence from the epididymis.

In this chapter we shall cover the wide variety of surgical diseases that are commonly found in the other elements of the spermatic cord, exclusive of the vas deferens, and shall consider the entire length of the cord from its junction with the epididymis to the external inguinal ring (scrotal portion) and also the portion lying between the external and the internal inguinal rings (inguinal portion). Surgical lesions and conditions occurring within the cord proper obviously constitute an important part of the pathological conditions calling for operative procedures within the scrotum.

This chapter will accordingly discuss the surgical anatomy and surgical pathology of the cord and the operative treatment that should be carried out in surgical conditions affecting this portion of the contents of the scrotum.

Pathological conditions of the testis and epididymis, as well as those of the scrotal pouch itself, have been covered by other writers and will not be discussed here.

SURGICAL ANATOMY OF THE SPERMATIC CORD

The spermatic cord, or funiculus, which suspends the testis and the epididymis in the scrotum, is composed of the spermatic vessels, nerves, and lymphatics, together with the vas deferens, the chief mass among these various components being a convoluted plexus of veins, known as the pampiniform plexus. All these structures are dragged along by the testis at the time of its descent through the abdominal wall into the scrotal pouch in the last

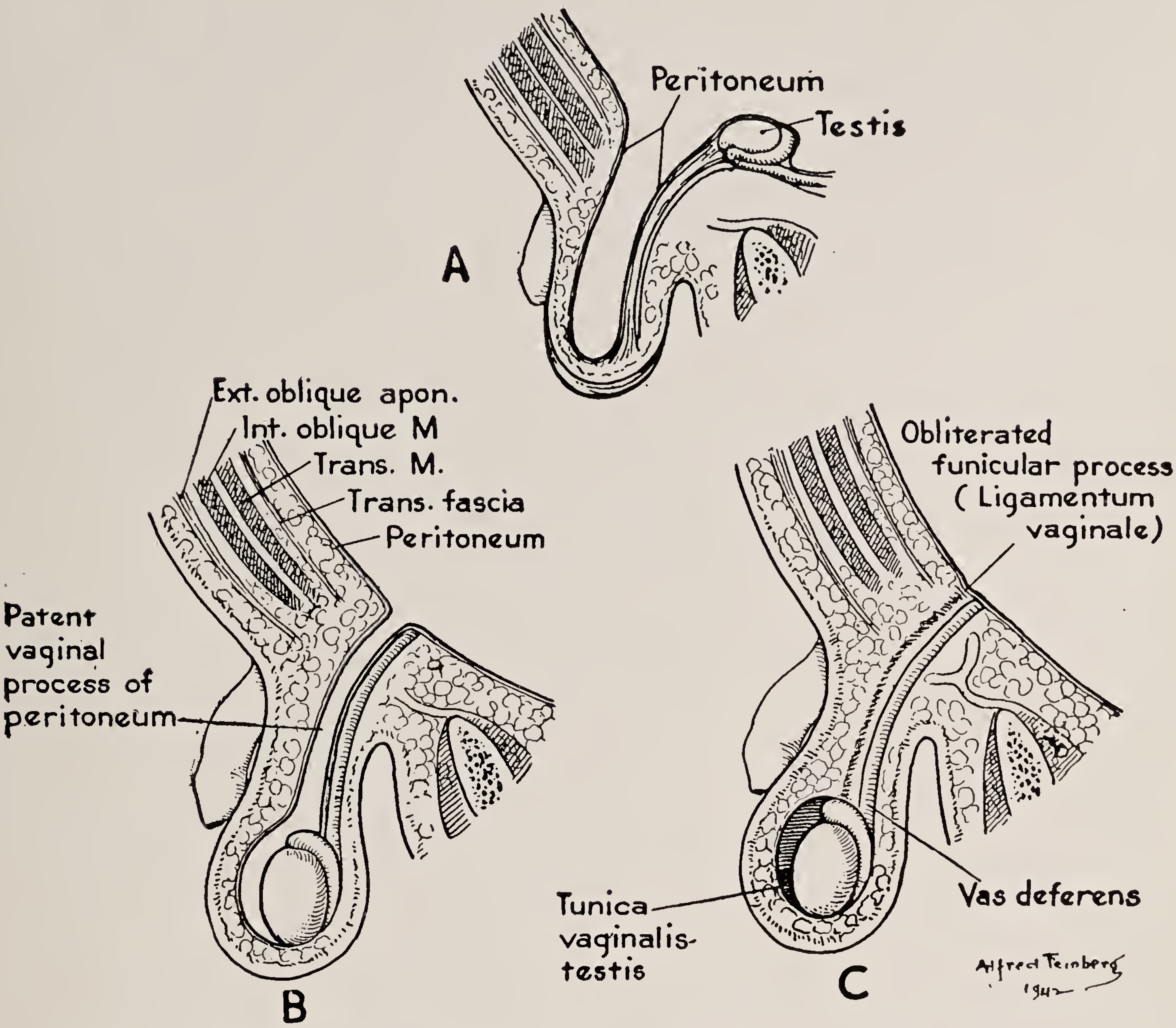


FIG. 47. Drawing to illustrate the embryological conception of the formation of the processus vaginalis from the peritoneum and its anatomotopographic relation to the descent of the testis into the scrotum.

A. In the last months of embryonic life the peritoneal sac lies wide open at the bottom of the scrotum, while the testis still remains in the abdomen.
B. At birth the testis, epididymis, and vas deferens are normally found within the scrotum; anatomically the anterior and posterior membranes of the processus vaginalis have approached each other but have not yet coalesced. If they fail later at any point of the cord to coalesce, the way is left open for the formation of various pathological conditions, such as hydrocele of the cord or of the tunica vaginalis propria.
C. The obliteration of the funicular processus has now been completed and the tunica vaginalis surrounds the testis in its normal position.

months of fetal life. In the adult, the left cord is a little longer than the right.

Membranes of the cord. The cord extends from the deep inguinal ring to the posterior margin of the testis. From the circumference of this ring a thin funnel-shaped membrane, derived from the transversalis fascia, and known as the *internal spermatic fascia*, is continued as a covering for the spermatic cord and testis. This membrane in its turn is covered by two other layers from the abdominal wall, namely the *cremasteric* and the *external spermatic fascia.*

The *cremasteric fascia* is composed of a number of small muscular bundles joined together by areolar tissue; they constitute the cremaster muscle, which is continuous with the obliquus internus abdominis. Outside this is the *external spermatic fascia*, a delicate fibrous membrane continuous with the aponeurosis of the obliquus externus abdominis, and constituting a tubular prolongation downward of the crura of the superficial inguinal ring.

Processus vaginalis. In the embryonic mechanism forming the tunica vaginalis and bringing about the descent of the testis, it appears that many different pathological processes may occur, and that these may, in fact, be the explanation of the pathological conditions frequently observed in the lower genital tract at birth or in adult life, as we shall see in our surgical discussion of hydrocele. At first, the peritoneal sac lies at the bottom of the scrotum, before the testis arrives there from its extraperitoneal abdominal descent (Fig. 47 A). The anterior and posterior layers of this peritoneal membrane then gradually approach each other and finally coalesce, having as a rule become firmly united by the time the testis reaches its final bed from behind and beneath the finished scrotum, which has now become a closed sac shut off from the peritoneal cavity (Fig. 47 C). However, these two membranes of the peritoneo-vaginalis process, after gradually approximating one another, may, for reasons not yet fully understood, remain apart, leaving an open canal from the scrotum to the peritoneum (Fig. 47 B). The lining membrane of this canal is the processus vaginalis, which in normal fetuses disappears with the closure of the canal at birth, but which, by its abnormal persistence in whole or in part, forms the basis for certain pathological conditions which may develop later, such as hydrocele and hernia.

The **tunica vaginalis communis** is the name given to the investing membrane covering the cord surface above the point where the **tunica vaginalis propria** of the testis comes to its upper limit just above the epididymis. All these anatomical structures and their topographical relationships from a surgical point of view are shown in Figure 48.

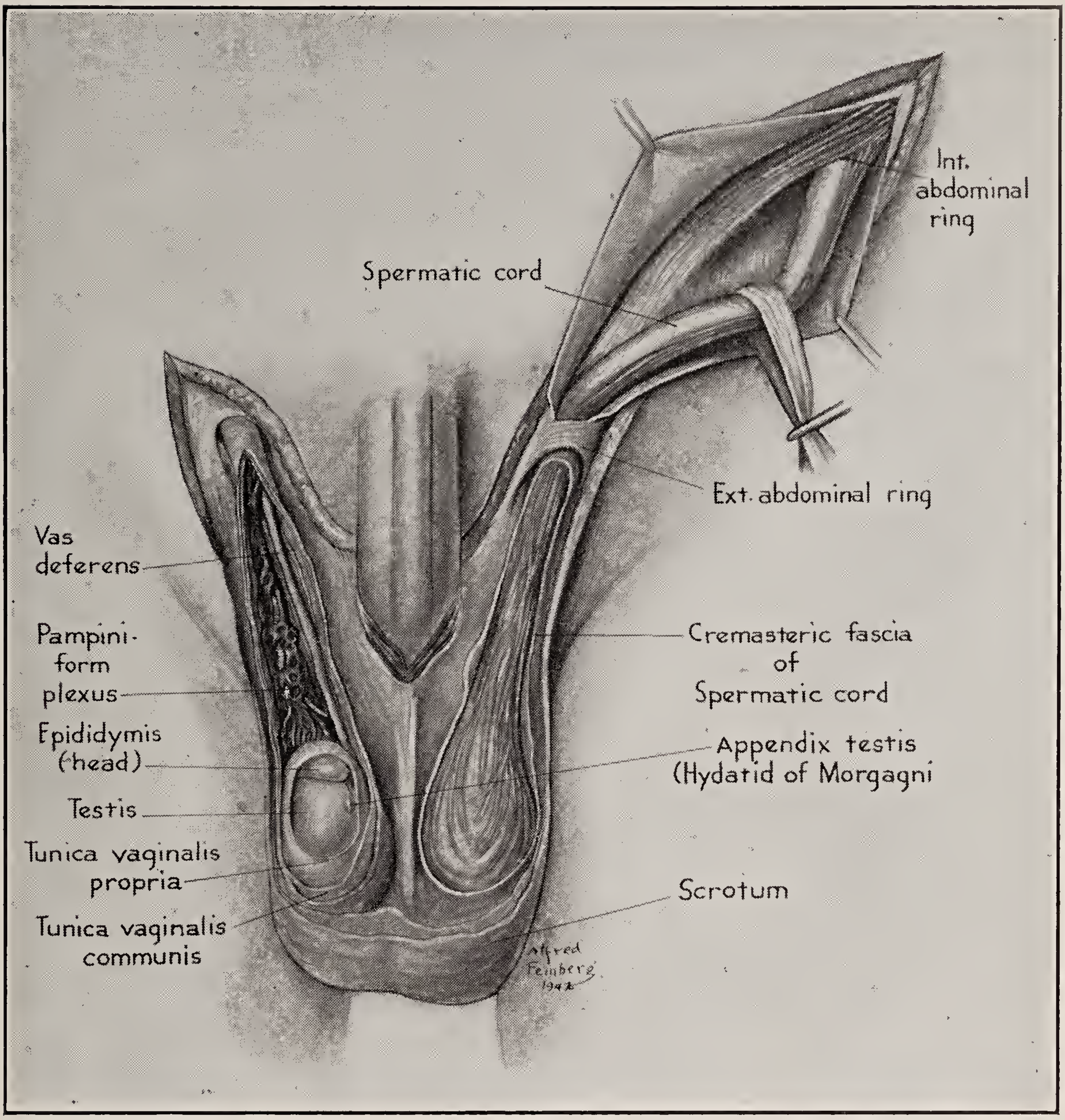


FIG. 48. Anatomotopographical relationships of the scrotum and its contents. The scrotum has been laid open, showing on the right side the elements of the cord, with the pampiniform plexus of veins and the vas deferens. The tunica vaginalis propria is partially open, disclosing the testis, epididymis and the appendix testis, or hydatid of Morgagni. On the left side the abdominal portion of the cord has been dissected and retracted, from the external inguinal ring to the internal ring; its scrotal portion is seen unopened, with the various layers of fascia that cover it. (Modified drawing largely after Testut.)

Arteries of the cord. The blood supply of the spermatic cord is furnished by 3 arteries: (1) the *testicular*, (2) the *cremasteric*, and (3) the *artery of the vas deferens*. The *testicular artery*, which is a branch of the abdominal aorta, passes out of the abdominal cavity at the internal inguinal ring together with the other components of the cord, then follows a course along the inguinal canal and through the external inguinal ring into the scrotum. Descending then to the testis, it becomes definitely tortuous and ramifies into several branches, some of which accompany the vas deferens, anastomose with its artery, and then supply the epididymis; while others go directly to the body of the testis. The *cremasteric artery*, otherwise known as the *external spermatic artery*, is a branch of the inferior epigastric artery, around the lateral and posterior surfaces of which winds the vas deferens. This artery supplies the cremaster and the other coverings of the cord, and anastomoses with the testicular artery. The *artery of the vas deferens* is a slender vessel originating from a branch of the superior vesical artery, or occasionally from the inferior vesical artery. This artery follows a long and tortuous course as it ramifies upon the coats of the vas, finally anastomosing with the testicular artery as it approaches the testis.

Veins of the cord. The *testicular veins*, which are very numerous, emerge from the testis and, receiving tributaries from the epididymis, ascend in front of the vas deferens, forming the *pampiniform plexus* already referred to; as they approach the inguinal ring, they anastomose to form 3 or 4 veins, which pass along the inguinal canal and through the deep inguinal ring into the abdomen, where they unite again to become 2 veins, and finally one, which on the right side opens into the inferior vena cava, while that of the left side enters the left renal vein, at a right angle. This anatomical disposition may account for the formation of varicocele more commonly on the left than on the right side.

Lymphatics of the cord. The lymph vessels from the testis, epididymis, and tunica vaginalis unite into 4 to 8 collecting trunks, which ascend in the spermatic cord with the testicular veins; they pass along the anterior surface of the psoas major and empty into the lateral and pre-aortic lymph glands.

Nerves of the cord. The nerve supply comes from the genital branch (*external spermatic nerve*) of the genito-femoral nerve, and also from the *testicular plexus* of the sympathetic. Crossing the lower end of the external iliac artery, the external spermatic nerve enters the inguinal canal through the internal ring; it supplies the cremaster and also sends a few filaments to the skin of the scrotum. The testicular plexus, which accompanies the testicular artery within the cord all the way to the testis, is derived mainly from the renal plexus and, to a lesser extent, from the aortic plexus.

CONGENITAL ANOMALIES OF THE SPERMATIC CORD

Congenital anomalies of the spermatic cord are almost always associated with anomalies of a testis, such as imperfect descent, or with congenital absence or anomalies of the vas deferens or other parts of the spermatic tract on one or both sides. The reader is referred to Chapter III on Anomalies of the Seminal Vesicles and Spermatic Tract, in which the subject has been discussed at some length.

In addition to the types of anomalies therein discussed, certain congenital malformations peculiarly related to the cord and of surgical importance in treatment of lesions of the inguino-scrotal contents should also be emphasized. Such are the congenital types of hydrocele of the cord, which will be discussed later; all types of scroto-inguinal hernia, both direct and indirect; hernia of a ureter into the scrotal portion of the cord, and scrotal hernia of the bladder or of a diverticulum of this viscus. Of interest also are cases in which, although a testis failed to descend, the cord, carrying the vas, has pursued its course down to the bottom of the scrotum, where it hangs in a long loop from the testis, which remains in or above the inguinal canal; also cases in which one or both vasa are blind at the lower end and do not unite with the globus minor.

Hermaphroditism, too, presents innumerable varieties of associated surgical anomalies within the elements of the spermatic tract, including the cord. These congenital malformations have been the subject of recent important contributions to the literature by Arey, Wood, Priesel, Radasch, and particularly by Young, who, in 1937, published an intensive study on the subject.

INJURIES OF THE SPERMATIC CORD

Injuries of the cord may affect any of its elements; they may involve the vas deferens, the arterial blood supply, the veins, nerves, or tunics. They may be contused, lacerated, or incised.

In rare instances gunshot wounds have been inflicted upon the cord.

In a general way, cord injuries may be classified as (1) contusions, (2) open wounds, and (3) wounds surgically inflicted during the course of some operative procedure.

Contusions. These consist of an effusion or ecchymosis due to rupture of a blood vessel beneath the skin, with extravasation into the cellular tissue. Such injuries may arise from a kick or sudden blow, or from a fall astride some hard object. They may also be due to strains by sudden and violent action, accompanied with abrupt abduction of the leg. Long-continued jolting or pressure, such as occurs in horseback riding, when the pommel of the saddle hammers the scrotum repeatedly for hours at a time, may produce contusions of the cord and its covering membranes, while the testis, better protected, glides easily to safety, due to its ready mobility.

Whenever a contusion arises, from whatever cause, a hematoma forms, which may be diffused throughout the surrounding parts, or may be localized within the cord, as the result of rupture of one or more of its abundant vessels. When the collection of blood is entirely within the cord or in the tunica vaginalis, it is within a pre-formed sac, and is therefore known as a hematocele. (See page 746 (535).)

Diagnosis generally presents no difficulty, since, as a rule, the history, together with the presence of acute symptoms, such as swelling and pain in the groin and scrotum on the side of the injury, leaves no doubt as to the nature of the condition. On physical examination by palpation, the injured part, when there is extravasation of blood into the tissues of the cord, exhibits ecchymosis, with swelling and bluish or purple color of the skin, and with thickness and inflammation of the cord. A hematoma may have already formed within the cord, and may sometimes extend into the tunica vaginalis. In fact, it is difficult to differentiate the many common complications that may arise, such as orchitis, epididymitis, and even torsion of the cord or one of its appendices. This is particularly true when the traumatism has been sudden and the patient has failed to receive prompt medical attention.

Treatment may be conservative or operative. Conservative treatment consists of rest in bed, the application of an ice bag, and a suspensory to immobilize the external genital organs. If, however, the acute symptoms persist, with evidence of a tender hematoma, accompanied by general constitutional disturbances and a markedly painful, fluctuating tumefaction of the cord, the wound must be opened in an effort to find the bleeding points. These should be promptly ligated to prevent further bleeding, after which proper drainage should be instituted.

Open wounds. Lacerated or incised wounds must be regarded from a different point of view, taking into consideration not only the type of injury but also the liability to infection, as well as the possibility that other elements of the scrotal contents may have been jeopardized. Hence the first consideration is twofold: (1) the control of hemorrhage and (2) the maintenance of the vitality of the testis. When the bleeding is profuse, every effort should be made to arrest it by ligature, having in mind the salvage of the testis. When this is not possible, and there is evidence of shock, a ligature *en masse* of the cord should be made. If the spermatic artery and, at the same time, the bundle of veins is ruptured, gangrene or atrophy of the testis may be the result. There may·be an aseptic necrosis or, if infection develops, a suppurative process, ending in destruction of the entire testis and epididymis.

If the vas has been sectioned, an end-to-end anastomosis is in order with a view to reëstablishing its continuity, thus preserving the function of the testis.

In considering an open traumatic injury of the scrotum, where the cord or any of its elements may have been ruptured, one must take into account the possibility that some other type of pathological condition may already have been present before the injury, such as hydrocele, spermatocele, or a tumor of the cord. Thus, the presence of a hydrocele before the traumatism would readily invite rupture of the tunica vaginalis, such instances having frequently been reported in the literature. If such a rupture is not properly treated, it may in some instances even eventuate in chronic vaginalitis and a calcified hematocele, as is pointed out in the section on hematocele.

Treatment of open wounds is always surgical, and must be adapted to the type of lesion present. Every bleeding vessel must be clamped and ligated separately if this is feasible; if not, the cord vessels must be tied in a bundle. Every effort must be made to combat infection, since, as a rule, this is fatal to the testis. In some of these open wounds of the scrotum, in which there has been loss of tissue, as in certain gunshot wounds, plastic procedures may be in order.

Wounds surgically inflicted. Sometimes in the course of an operation, especially for inguinal hernia, the cord with its elements, including the vas deferens, is accidentally sectioned, excised or ligated, resulting in atrophy of the testis. Such wounds, which include destruction of the vas deferens, are unfortunately not uncommon.

As operations for recurrent inguinal hernia are sometimes quite difficult, since the cord has to be transplanted (as in the Bassini procedure for anatomical reconstruction of the abdominal wall), some clinics have deliberately adopted the practice of excising the whole length of the cord lying between the external and internal inguinal rings, in order to remove the cause of the recurrence, facing the fact that atrophy of the testis will follow. It has recently been demonstrated, however, by Neuhof and Menscher that the blood supply of the testis has been well protected by nature from complete destruction. These authors performed unilateral severance of the cord in 25 patients in an effort to obtain hernioplastic closure of the abdominal wall. Of 19 cases that were followed for 8 to 55 months, atrophy of the testis developed in only 32 per cent., slight atrophy in 10 per cent., and little or no atrophy in 57 per cent. These authors proved that there is a collateral circulation, of which the cremasteric artery is the key vessel, between the testiculo-cremasteric-deferential arterial system, on the one hand, and the scrotal arterial system on the other, and that this collateral circulation is unaffected by severance of the cord. They demonstrated that if an aseptic and hemostatic technic is carefully carried out, this collateral circulation will preserve the life of the testis in the majority of cases in which an incised operative wound has jeopardized it. Nevertheless, it need hardly be said that every effort should be made to avoid operative injuries of the cord, and to save the life of the testis.

Atrophy of the testis may also result from surgical injury of the cord inflicted during an operation for undescended testis. Among other common injuries of the cord that may be caused by operative interference are those inflicted by needle aspiration of a hydrocele or spermatocele, as well as those caused by injection of sclerosing substances, particularly in the treatment of hydrocele, varicocele, and other conditions of the scrotum.

Treatment. Wounds surgically inflicted may or may not require further surgery for their relief, according to the type of injury or complication resulting. Thus, if there is a section of the vas during any surgical procedure in the inguino-scrotal region, an end-to-end anastomosis is indicated in order to save the testicular function. If the injury has produced a hematoma or a hematocele, further surgery is indicated to control the bleeding vessel and to institute proper drainage.

TORSION OF THE SPERMATIC CORD

Definition. Torsion or twisting of the spermatic cord upon its axis was formerly considered a rare condition, but it is now known to be by no means uncommon. The degree of rotation may be from a half turn to several turns, and its direction may be either clockwise or counter-clockwise. The first case is said to have been reported by Delasiauve, in 1840. By 1901 Scudder had collected a total of only 32 cases, but as the idea gradually took root that many cases formerly diagnosed as unexplained gangrene were actually due to unrecognized torsion, cutting off the circulation of the testis, and preventing return flow of the venous blood, reports increased in number, to such an extent that Abeshouse, in 1936, was able to find 350 cases in the literature, and Kreutzmann and Strauss, in 1939, had brought the number up to fully 450. An acute and a recurrent type are recognized, with acute cases constituting about 80 per cent., according to O'Conor, who studied a collection of 124 cases. The recurrent type was first recognized by Nicoladoni in 1885. It is often mistaken for epididymitis or orchitis, and fails of recognition until some more severe attack recurs at a later date. The majority of cases occur at the age of adolescence or in early adult life. The incidence is a little higher on the right than on the left side.

Etiology. All authors are in agreement that torsion of the cord cannot occur where there is a perfectly normal testis. There must be some abnormality either of size, position, or attachment that permits increased mobility of the organ, thus furnishing the anatomical conditions necessary to induce rotation. Torsion occurs more frequently in cases in which there is an incompletely descended testis than in others. O'Conor found 72 of the former, and 52 of the latter. When the testis has no firm attachment to the bottom of the scrotum, or has an abnormal type of fixation, torsion of the cord is readily brought about by sudden or repeated contraction of cremasteric fibers in cases where, according to Uffraduzzi and others, the strands of those muscle fibers are themselves anomalous.

Given this faulty anatomical groundwork, any sudden violent strain, or even slight exertion, such as a cough or abrupt change of position, may be the exciting cause of rotation. Such rotation occurs just above the testis, within the upper limits of the tunica vaginalis, where it merges into the tunica communis of the cord. This is the *intravaginal type* of torsion. More rarely the cord rotates outside of the tunica vaginalis, constituting the *extravaginal type.* Not infrequently the torsion occurs during sleep.

The degree of torsion will depend *directly* upon the degree of mobility of the testis, and *indirectly* upon the strength of the pull exerted by the cremaster. It was pointed out by Davis and Colle that the fact that the majority of cases are observed around the age of puberty is related to the increased vascular arrangement that arrives at this time of life, to which the cord must adapt itself. Torsion may, however, occur at any age, having been observed in infants and in persons who have reached old age.

Symptoms. In nearly all acute cases the symptoms are about the same, consisting in the sudden occurrence of excruciating pain in the groin, accompanied by swelling in that region. If the testis and cord are undescended, the picture resembles and suggests that of strangulated hernia, for which it is frequently mistaken. The groin may be exquisitely tender to pressure. Injury to nerves at the site of torsion generally causes reflex constitutional symptoms, expressed in nausea and vomiting, with colicky pains resembling those of intestinal obstruction. The skin over the strangulated testis becomes edematous and red, with discoloration that may extend past the midline, while the cord above the twist is normal. At first there is no change in temperature, but as a rule chills and fever ensue, the temperature in some cases reaching 104° F. as gangrene develops. With the development of gangrene, the pain ceases to increase, after 24 to 48 hours.

Sometimes the muscular pull on the cord from above is so great that a scrotally placed testis is drawn up from its normal position and disappears in the region of the external ring. When the testis and cord are within the inguinal canal, all symptoms are exaggerated, with signs of severe shock and a state of general prostration. In such cases a localized peritonitis may even occur.

In the milder, recurrent cases the symptoms resemble more those of a chronic epididymitis, and are of relatively short duration, yielding in a few hours if detorsion takes place spontaneously or can be brought about by manipulation, as is frequently the case.

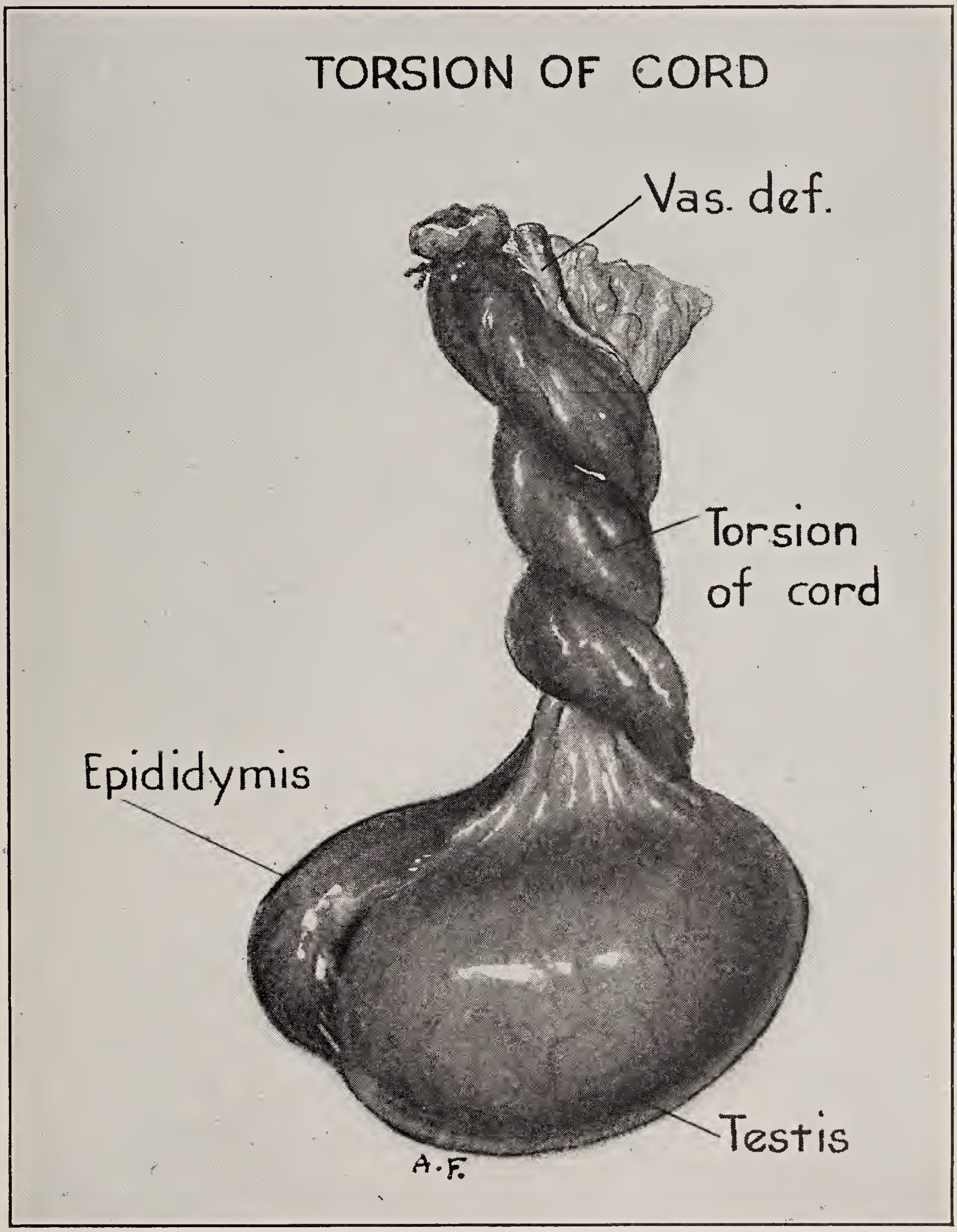


FIG. 49. Torsion of the spermatic cord with gangrene of the strangulated testis and epididymis. The markedly edematous cord has been ligated and resected above the point of torsion. The entire hemorrhagic and gangrenous mass has been removed by orchidectomy. (Drawing from author's case.)

Pathology. According to the extent to which the vessels are occluded, they become dilated above and below the point of torsion, or they are flattened and obliterated. The spermatic artery generally remains partially pervious. Early incision into the tunica vaginalis elicits blood-stained fluid; in cases that have waited longer, the tunica is filled with old blood clots. Below the point of torsion the cord is a swollen, contorted mass, of a bluish or purple color from strangulation of its intricate plexus of veins; section reveals the presence of a generalized thrombosis. The testis may be only slightly enlarged if operation is prompt; but if there is a delay of more than a few hours, it may already be swollen to twice its normal size, with everything below the twist a hemorrhagic infarct. In such a case gangrene is inevitable. (See Fig. 49.) Even in the milder cases, of long standing, with detorsion and subsequent recurrence, the testis if left in the scrotum almost inevitably undergoes atrophy and suffers an aseptic death, which is not strictly a necrosis but a gradual fibrotic transformation until it is completely useless.

Diagnosis. It is rare for the correct diagnosis of torsion of the spermatic cord to be definitely made without an exploratory operation. The first requisite, however, is that the surgeon shall bear the condition in mind. Since most of these cases occur in the young, at the age of puberty, the probability of an epididymitis or an orchido-epididymitis from urethral infection, for which the symptoms might be mistaken, is not great. The latter can be ruled out by the history of a sudden trauma from a blow or fall, by rectal palpation of the prostate and seminal vesicles, and by examination of the urine and the prostatic secretion. The patient with torsion is likely to give a history of abnormal mobility of the testis, which may have disappeared more than once within the inguinal canal. In some cases there is history of a previous attack with similar symptoms. On inspection, acute localized inflammation is observed in the scrotum, if the testis is normally placed; characteristic redness and swelling, with edema, extend to and beyond the midline. An exquisitely tender mass is palpated in which it is difficult or impossible to make out the line of demarcation between epididymis and testis. If the testis is in the inguinal canal, palpation is useless. Differentiation from strangulation is then almost impossible. In fact, differentiation from incarcerated or strangulated hernia is exceedingly difficult without open operation. Other possible diagnoses, such as hydrocele, hematocele, cord tumor, tuberculosis, ruptured varicocele, or lymphadenitis can more easily be ruled out. The possibility of acute appendicitis must also be borne in mind. The correct diagnosis will rest mostly upon the sudden onset of symptoms, their severity, and in many cases the youthful age of the patient.

Errors in diagnosis are not infrequent if several days have elapsed before the patient is examined. This is especially true when a hematoma of considerable size has already formed, involving the testis, epididymis, and cord in a solid indurated mass, as in a case on which the author had the opportunity to operate and in which the diagnosis of torsion was made at the time of operation. The operative findings of this case are shown in Figure 49.

Treatment may consist of (1) conservative measures, such as immediate detorsion and suture of the testis to the bottom of the scrotum, (2) castration. No time is to be lost by applying expectant treatment. If it is found possible to untwist the cord, this should be done at once, either with or without exposure by open operation, provided gangrene has not set in. Detorsion without operative exposure may be difficult, for the surgeon cannot know in which direction the twist has occurred. If the direction for untwisting that is first chosen is the wrong one, he will know it by the increased pain and the resistance offered by the cord. If an attempt in the opposite direction also fails, and the cord cannot be set right even under full vision, nothing remains but castration. This is definitely indicated also if gangrene is present or threatened. The cord is ligated high up, and its swollen mass removed with the testis and epididymis. Where the twist of the cord of an imperfectly descended testis has been tight, and attended by extensive engorgement of the organ and epididymis, suppuration will probably occur during a slow convalescence. A testis that has never reached the scrotum and that cannot be fixed there is usually functionally imperfect, and after an attack of torsion of its cord it is always liable, even if detorsion can be accomplished, to be a source of inconvenience at some future time.

Prognosis. A small number of mild cases are on record in which detorsion occurred spontaneously and the first attack was never followed by another. These are exceptional. The rule is that a first mild attack is followed by others, since the cause is an anatomical defect that continues to act recurrently, finally resulting in atrophy of the testis unless orchidopexy is carried out to anchor the testis to the bottom of the scrotum.

In acute cases, accompanied by violent pain and marked engorgement of the cord, radical operative interference is imperative, without an hour's delay, lest gangrene set in. If this occurs, castration is the only recourse since the testis is already lost.

In some fatal cases of gangrene of the scrotum it appears that the origin of the condition lay in an undiagnosed primary torsion of the cord.

Torsion of appendices of the spermatic cord. Occasionally there may be torsion of some one of the vestigial appendices or rests of fetal structures found attached to the lower spermatic tract, which may be mistaken for torsion of the cord itself. There are 5 of these appendices, 2 of which, the vas aberrans inferius and the vas aberrans superius, arise from the vas deferens, the former at the point where the ductus epididymidis becomes the vas deferens, and the latter at a point farther up on the vas deferens.

In Figure 50, I have illustrated graphically the approximate anatomotopographic relationship of these minute embryonal structures to the vas deferens, epididymis, and testis. The purpose of this drawing is to bring out not only the anatomical position of the points where torsion occurs, but also the tendency to cyst formation, and to emphasize the importance of this clinical entity among surgical affections of the cord.

These 5 blind appendices or diverticula of the lower spermatic tract have been anatomically identified by Testut, Poirier, Sappey, and others as follows:

(1) The appendix of the testis, or sessile hydatid of Morgagni, attached to the upper pole of the testis.

(2) The appendix of the epididymis attached to the head of the epididymis.

(3) The paradidymis, or organ of Giraldès, found between the globus minor and the lower pole of the testis.

(4) The vas aberrans inferius, or vas aberrans of Haller, located at the lowest portion of the vas deferens.

(5) The vas aberrans superius, or vas aberrans of Roth, located at a site higher up on the vas deferens.

Any one of these spermatic diverticula may undergo hypertrophy and develop surgical lesions such as the torsion of a cyst or formation of a fibroma.

The first case reported in which torsion of one of these appendices occurred was one seen by Ombrédanne in 1913, and listed by him among 7 cases of torsion of the cord in children upon which

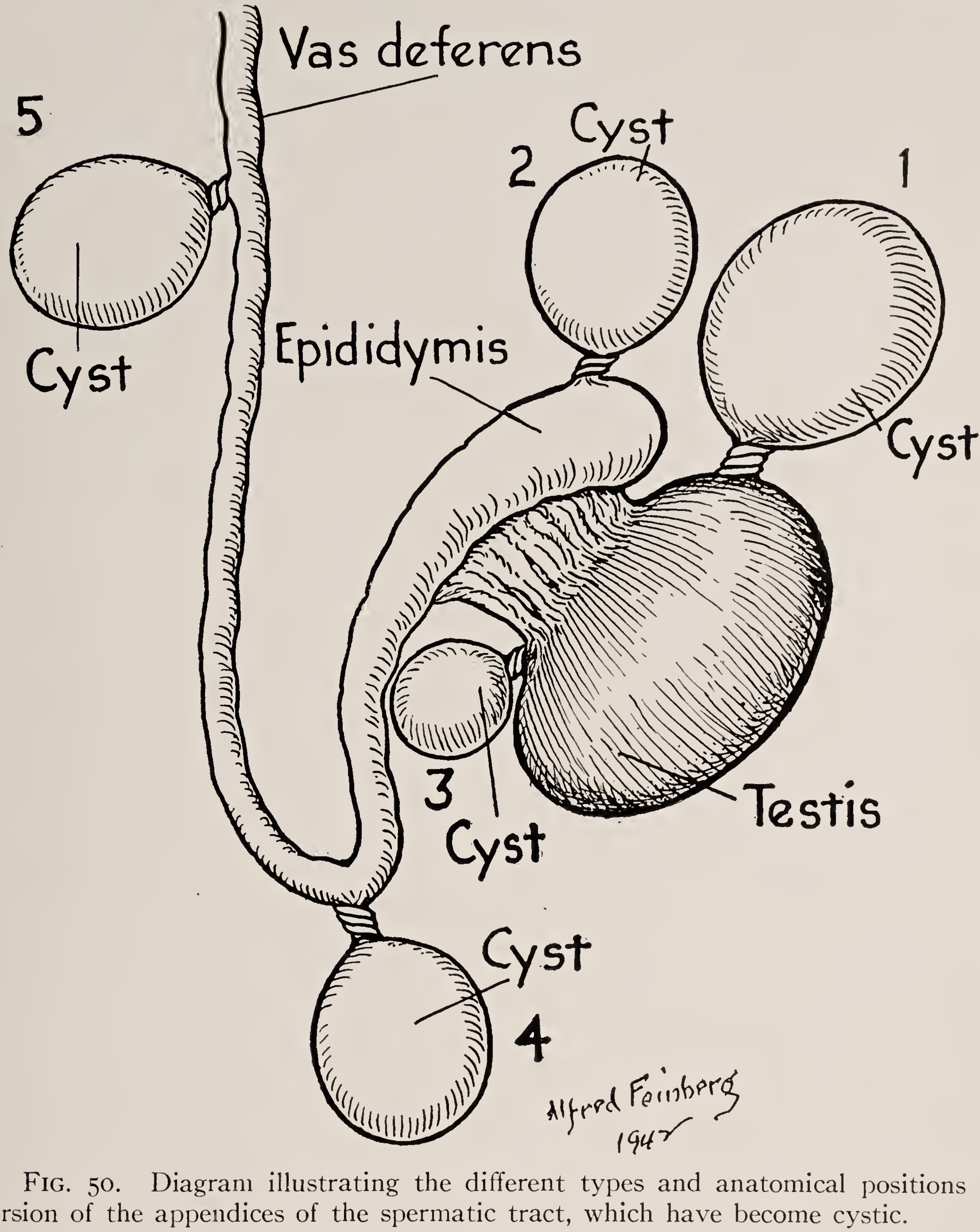


FIG. 50. Diagram illustrating the different types and anatomical positions of torsion of the appendices of the spermatic tract, which have become cystic.

1. Torsion of the appendix testis, or hydatid of Morgagni.
2. Torsion of the appendix epididymidis.
3. Torsion of the paradidymis, or organ of Giraldès.
4. Torsion of the vas aberrans inferius, also called the vas aberrans of Haller.
5. Torsion of the vas aberrans superius, or vas aberrans of Roth.

The last two arise from the vas deferens. Any one of these five appendices may undergo torsion and give the same acute symptoms as those observed in torsion of the cord.

he had operated. He made the comment that, at operation in this case, he found no torsion of the cord, but removed a red, pediculated hydatid of Morgagni, with a black and gangrenous tip, which operation was followed by prompt relief. He appears, however, not to have realized that he was dealing with a torsion of the hydatid of Morgagni.

Since Ombrédanne's report, more than 100 cases of this type of torsion have been recorded in the literature, notable among which are those of Colt (1922), who first gave a full description, and of Walton and Shattock (1922), who discussed 2 cases on which they had operated. The literature has been ably reviewed by Dix (1930), Roche (1935), Randall (1937), and Scott (1939). In March, 1942, Baird gave a detailed account of a case of torsion of the vas aberrans inferius due to a cystic formation. Edington (1936) described a similar case, differing only in that the cyst was in an extravaginal position within the cord tissues.

These vestigial tubes or diverticula, which may be closed or open, are normally found within the spermatic tract, and usually produce no disturbances. If they enlarge, however, they may give rise to cysts containing spermatozoa, which accordingly fall into the class of spermatoceles. When such cysts develop from the vestigial vasa aberrantia, they serve to explain the formation of cord spermatoceles.

As the cyst progresses in size, and moves freely on its pedicle within the cellular space of the layers of the cord, it is bound to undergo torsion. As soon as there is a twisted pedicle, shutting off the blood supply, the cyst may readily become gangrenous and produce symptoms identical with those commonly observed in torsion of the cord proper. It is therefore important to recognize the possibility of this condition as a clinical entity, as important as torsion of the cord itself, and equally demanding open surgical treatment for its relief.

These rudimentary spermatic cysts may be extravaginal or intravaginal; one should therefore explore both the cord and the tunica vaginalis when operating for an acute condition of torsion of the cord, since the true cause of the symptoms may be a torsion of one of these embryonic cysts, hidden inside or outside of the tunica vaginalis propria, according to its site of origin.

HYDROCELE OF THE SPERMATIC CORD

Definition. The term hydrocele has been applied somewhat loosely to any abnormal accumulation of fluid within the enveloping tunics of the testis and the spermatic cord. Such an accumulation may be *acute,* as the result of some injury or local inflammation, or it may be *chronic.* It may also be classified as *congenital* or *acquired,* and as *unilateral* or *bilateral.*

Properly speaking, hydrocele is a common chronic affection of the tunica vaginalis of the testis or of a persistent processus vaginalis of the spermatic cord that failed to undergo its normal obliteration at an early age and remains as a permanent investment of the cord. But for the sake of convenience and because anatomically the picture is in a general way similar, consisting in the presence of a collection of fluid in an abnormal sac, acute effusions into the tunics are also spoken of as hydroceles, though incorrectly. Occasionally an acute hydrocele becomes a chronic hydrocele through failure of its contents to undergo prompt reabsorption.

Character of the fluid content. The fluid within the ordinary hydrocele is closely related to ordinary serum. It is clear and transparent, has no odor, and varies in color from pale straw to green, or, if mixed with blood, takes on a reddish or brown hue. Under certain conditions it contains cells from the sac that are undergoing fatty degeneration; it also contains considerable amounts of alkaline carbonates and sodium chloride, as well as endothelial cells, cholesterin crystals, leukocytes, serum, albumin, and globulin.

Amount of fluid content. The amount will vary with the size of the sac and its anatomical location. When the sac of the hydrocele is extravaginal and is therefore located in the cord, as a rule the amount of the fluid is much smaller than when dealing with a hydrocele of the tunica vaginalis propria. In the average case, it is from 2 to 4 or from 4 to 12 ounces. In exceptional cases, where there is a huge sac, the amount is much greater, not infrequently reaching a pint or even a liter. The historian Gibbon is said to have had a hydrocele from which 6 quarts of fluid were drawn. Sometimes the fluid of the hydrocele of the cord may communicate with the cavity of the tunica vaginalis, constituting another variety, in which the fluid may be found at the time of operation to be contained in one or more compartments or subdivisions of the sac, thus complicating the original process and the amount of fluid of the hydrocele.

Course of development. Rarely does the physician have the opportunity to examine the early stages of a hydrocele when the formation is not congenital. Jacobson, in 1893, noted that patients came back for periodic tapping for years, without any enlargement of the testis or cord, and with no urinary troubles. The increase in size is slow, gradual, and insidious. The parietal and visceral layers of the tunics, which are normally in apposition, are so gradually separated by the accumulating fluid that it is difficult, in an acquired hydrocele, to say when the development of the sac began.

Etiology. There is no unanimity of opinion as to whether the common acquired hydrocele is of inflammatory origin and always secondary to some other pathological affection of the scrotum and its contents (orchitis, epididymitis) or other parts of the genito-urinary tract, or is primary and idiopathic, without assignable cause — a mere passive process due to unrecognized anatomical and mechanical conditions of the circulation in the cord and tunics. In hydrocele of congenital origin, on the other hand, the predisposing anatomical conditions in fetal life are well known, as may be seen in the accompanying plate, where they are graphically illustrated. (See Fig. 51–I, A, B and C.)

Classification. As our concern here is only with hydroceles of the spermatic cord, the various types of such hydroceles will mainly be discussed. It is so common, however, to meet various combinations of hydroceles of the cord and hydroceles of the testis, both being due to the same congenital or acquired anatomical conditions, and so frequently associated together, that it is impossible to separate the subjects completely. Both are accordingly included in the table of classification here presented.

Ordinary hydrocele. The most common type of hydrocele is that of the tunica vaginalis (Fig. 51–I, A), which may be either congenital or acquired. Here the sac containing the fluid is limited to the tunica vaginalis propria, and is illustrated here simply for the purpose of comparison with hydrocele of the spermatic cord in its many varieties.

Congenital funicular hydrocele. In this commonest of the several congenital types of hydrocele of the cord, so common, in fact, that the term *congenital hydrocele* is specialized for it (Fig. 51–I, C), the upper, or peritoneal, end of the processus vaginalis

CLASSIFICATION OF HYDROCELES

- I. Hydrocele of the Testis
  - (a) Hydrocele of the Tunica Vaginalis (Vaginal Hydrocele)
    - 1. Ordinary Hydrocele. — The fluid is within the closed sac of the tunica vaginalis.
    - 2. Congenital Hydrocele. — There is a communication between the cavity of the tunica vaginalis and that of the peritoneum.
    - 3. Infantile Hydrocele. — The tunica vaginalis and the funiculo-vaginalis processus are distended with fluid, but do not communicate with the peritoneal cavity.
    - 1. Bilocular Hydrocele. — The sac is abdomino-inguino-scrotal in type.
  - (b) Encysted Hydrocele. The fluid is in a sac distinct from the sac of the tunica vaginalis
    - 1. Encysted Hydrocele of the Epididymis. — The fluid is in a cyst adjoining the epididymis.
    - 2. Encysted Hydrocele of the Testis. — The fluid is encysted between the tunica albuginea and the tunica vaginalis.

- II. Hydrocele of the Cord
  - (a) Diffused. — The fluid forms a serous collection of an edematous nature within the cellular tissue of the cord, and is not true hydrocele.
  - (b) Encysted. — The fluid is within a distinct sac, originating in (1) some unobliterated part of the processus vaginalis; (2) a cyst formed independently of the processus vaginalis; 3) vestigial remnants of the vas, testis, or epididymis.
  - (c) Congenital. — The fluid is contained in the funiculo-vaginalis processus, which is closed off from a cavity of the tunica vaginalis, but not from that of the peritoneum.

- III. Complications of Hydrocele
  - 1. More than one type of hydrocele present.
    - (a) Hydrocele of tunica vaginalis with encysted hydrocele of testis.
    - (b) Hydrocele of tunica vaginalis with encysted hydrocele of the cord.
    - (c) Hydrocele of tunica vaginalis with diffused hydrocele of the cord.
  - 2. Inguinal hernia associated with
    - Hydrocele of tunica vaginalis.
    - Hydrocele of cord.
    - Hydrocele of tunica vaginalis of an undescended testis.
  - 3. Hydrocele associated with other lesions of scrotum.
    - Rupture of sac
    - Torsion of cord
    - Hematocele
    - Spermatocele
    - Lymphocele
    - Pyocele
    - Varicocele
    - Tumor
    - Tuberculosis
    - Calcification
- IV. Hydrocele of the Sac of a Hernia
  - Inguinal
  - Scrotal
- V. Hydrocele of the Canal of Nuck (Hydrocele in the Female)

remains patent owing to nonobliteration of this processus, a condition which is commonly observed in the newborn. When this condition persists to adult age, a peritoneal sac, open at the top, is formed which extends all the way from the peritoneum down to the bottom of the scrotum, and may follow along the line of the inguinal canal. In view of the fact that the peritoneum is open at the external ring, this congenital type is very frequently accompanied with hernia of the gut and sometimes even of the bladder, giving rise to many complications, such as strangulated hernia and urinary disturbances.

Changes in the size of this type of hydrocele can be observed from time to time, the swelling in the scrotum being now larger, now smaller, according as the fluid is running into the abdominal

HYDROCELE

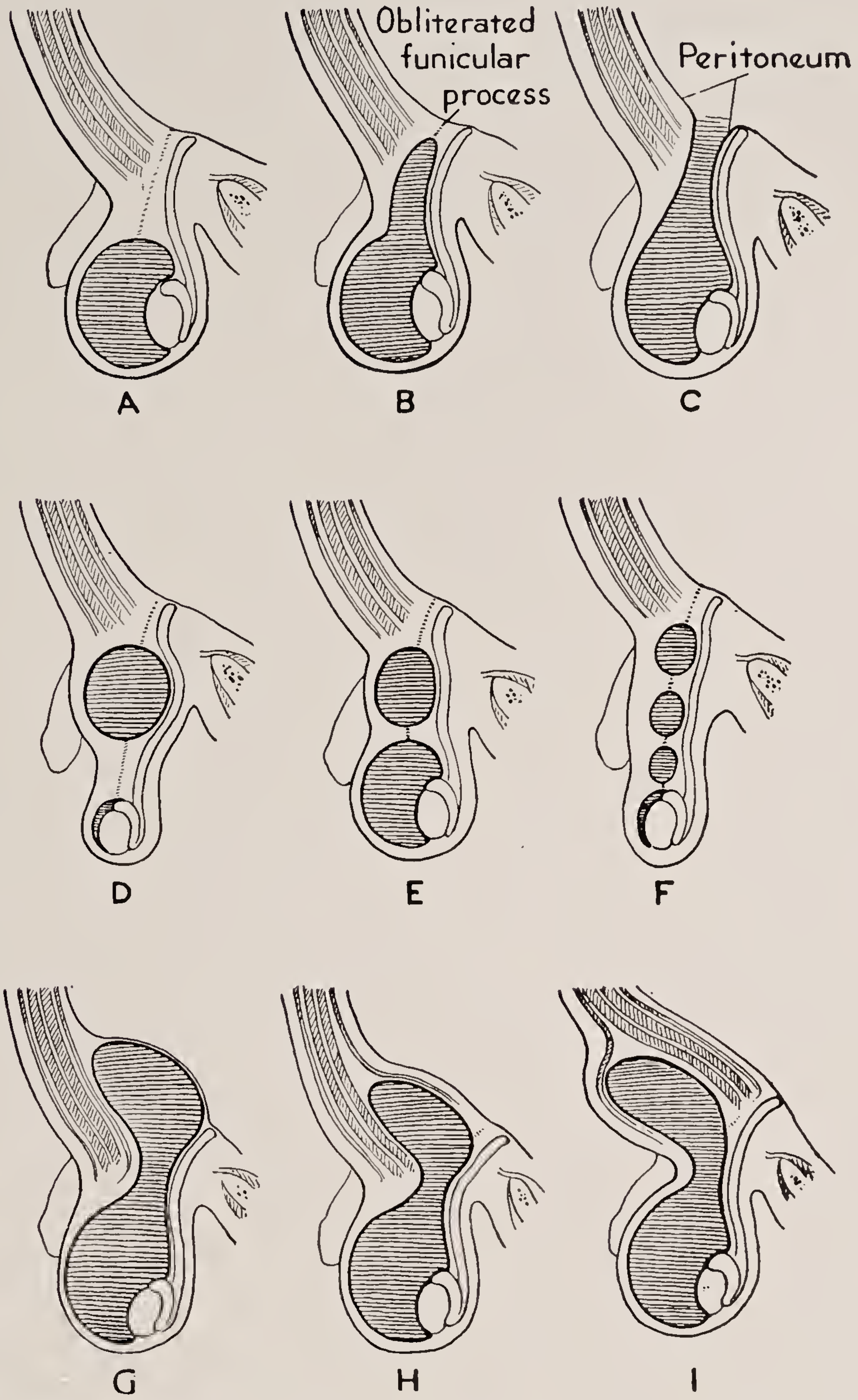


Fig. 51–I. Illustrating the different types of hydrocele of the cord and tunica vaginalis, and their most common complications.

A. Ordinary hydrocele of the tunica vaginalis propria. B. Infantile type of hydrocele of cord. C. Congenital funicular hydrocele. D. Encysted hydrocele of cord. E. Association of encysted hydrocele of cord with hydrocele of tunica vaginalis. F. Multiple encysted hydrocele of cord. G, H, I. Bilocular hydrocele. Illustrating the 3 different anatomical positions that may be assumed by this abdomino-inguino-scrotal pouch.

cavity or into the sac, with corresponding variations in tenseness, both size and tenseness being reduced when the patient lies for some time in the recumbent position or when gentle bimanual compression is applied to the scrotum, using the same manipulation as in taxis or in reduction of a scrotal or inguinal hernia. The fluid in this type is most frequently derived from the peritoneum, at the external inguinal ring, by trickling through the open orifice, but it may be secreted also by the vaginal sac and processus.

Infantile type of hydrocele of cord. This differs from the preceding by closure of the very uppermost part of the processus vaginalis so that there is no communication with the peritoneal cavity, while the remainder of the processus vaginalis persists as a sac (Fig. 51–I, B). This hydrocele, like the preceding, involves both the cord and the tunica vaginalis. It is irreducible and is sometimes associated with undescended testis or inguinal hernia.

Encysted hydrocele of cord. In this type the funicular portion of the tunica communis vaginalis has been cut off from the cavity of the peritoneum at the upper end, and from the cavity of the tunica vaginalis at the lower end, but has left a sequestered oval sac of encysted fluid midway in the cord, originating in what remains of the funiculo-vaginal processus. It may, however, originate in a cyst formed independently of this. In some cases there is found, instead of a single cavity, a series of such cavities forming a sort of disconnected chain along the length of the cord, all filled with fluid, constituting multiple hydrocele of the cord (shown in Fig. 51–I, D, E, F). This type of hydrocele of the cord may be associated with hydrocele of the tunica vaginalis and hernia and varicocele, as occurred in a case upon which the author has recently operated.

Bilocular hydrocele (hydrocele en bissac). This is a hydrocele constricted at some point in such a way as to divide it into two pockets or lobes, an upper and a lower, separated by a narrow neck which gives it an hour-glass shape, with the upper pouch, which is generally secondary, existing as a diverticulum of the lower. This upper pouch may be carried far into the abdominal cavity, sometimes even to the level of the umbilicus, while the lower one may descend to the testis, the whole constituting an enormous smooth, round tumefaction in the groin. The constriction is frequently at the inguinal ring, but may be elsewhere. The upper sac may exert pressure upon the bladder, causing retention or dysuria.

Anatomically, the abdominal sac of such a hydrocele, which does not communicate with the peritoneum, may occupy any one of 3 positions: (1) between the peritoneum and the abdominal muscles (Fig. 51–I, G), (2) between the transversalis fascia and the transversalis muscle (Fig. 51–I, H), (3) directly under the abdominal wall, and covered only by the aponeurosis of the external oblique muscle (Fig. 51–I, I). These abdominal positions of the sac of the bilocular hydrocele are of great surgical importance. As a rule, the hydrocele en bissac is found in the inguino-scrotal region, following the course of the spermatic cord, and extending from the external to the internal inguinal ring; but in some instances it may reach upward to the hypogastrium and laterally to the midline of the body, thus becoming an abdomino-scrotal hydrocele, as in cases reported by Delbet, Bazy, Coleman, Perrier, Hermann, Curtis, Cummins, and many others.

Diffuse hydrocele. Here a serous collection which is of the nature of an edema has formed within the loose cellular tissue of the cord, such as might develop anywhere else in the body under appropriate conditions. This is not a true hydrocele and should not properly be called such (Fig. 51–II, J). It may, however, coexist with hydrocele of the tunica vaginalis, with a small cyst or hydrocele of the cord, or even with an inguinal hernia or an epiplocele.

Funicular hydrocele associated with inguinal hernia. It is quite usual for congenital funicular hydrocele to be complicated with inguinal or scrotal hernia. The ease with which a loop of intestine can prolapse into an open hernial sac of a congenital hydrocele may be seen in Figure 51–II, M. These cases occur for the most part in childhood and are seen in anemic and poorly nourished individuals. The gut can enter only a certain distance into the hydrocele sac, being prevented from reaching the floor of the scrotum, in some instances, by the fluid contained within the sac. Hernia may also occur in an infantile type of hydrocele. Here the hernia can usually enter the hydrocele only as far as the external inguinal ring or a point just below it, where the constriction begins.

A hydrocele of the cord or of the tunica vaginalis may also coexist with a direct or indirect inguinal hernia (Fig. 51–II, N, L), or with a cyst independent of both of these structures (Fig. 51–II, O).

Hydrocele of cord in undescended testis. A hydrocele of the

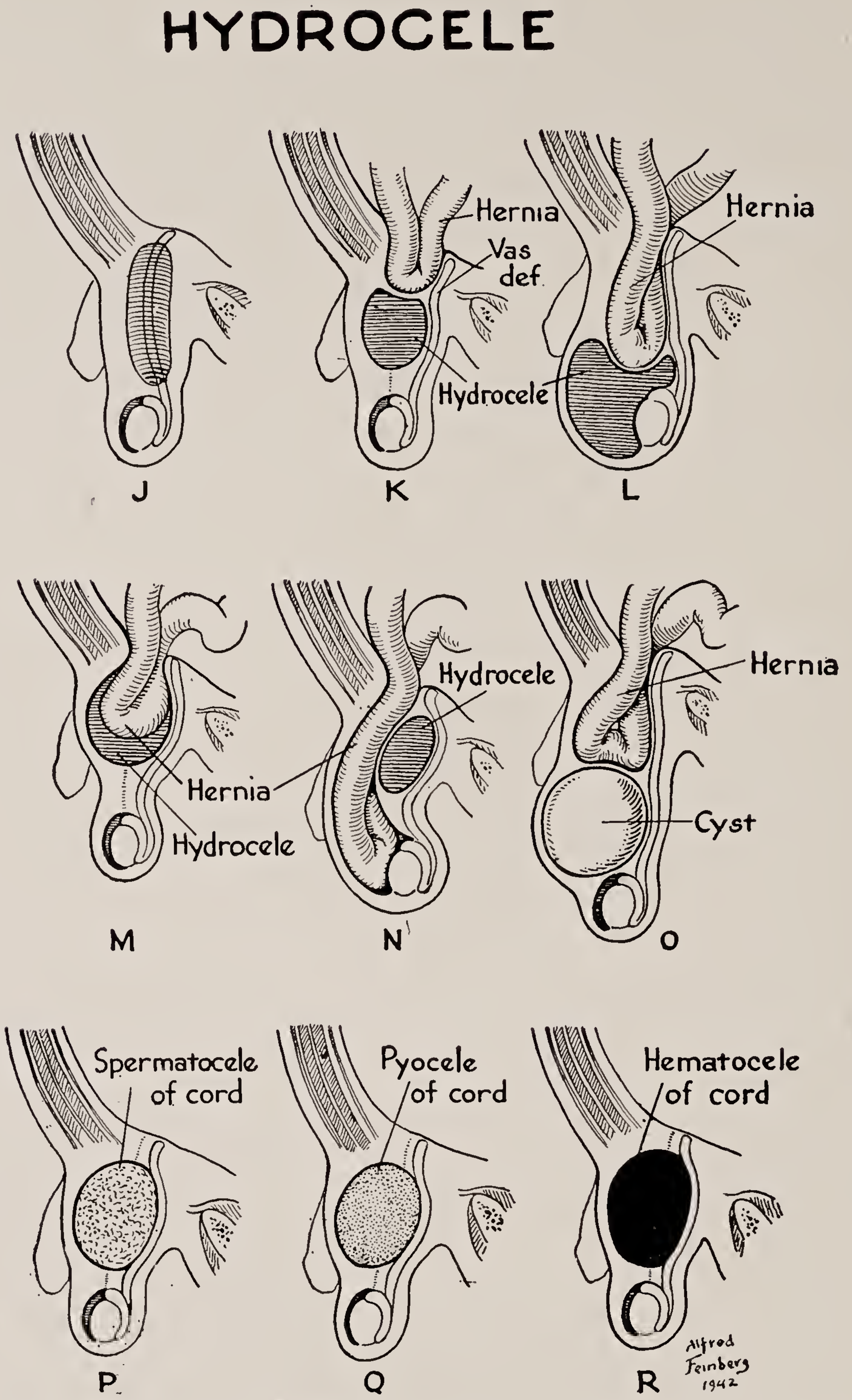


FIG. 51–II. Illustrating the different types of hydrocele of the cord and tunica vaginalis and their most common complications.

J. Diffuse hydrocele of cord. K. Drawing to illustrate the association of a hydrocele of the cord with inguinal hernia. L. Hydrocele of the tunica vaginalis compressed by an inguino-scrotal hernia. M. Hydrocele of the sac of a hernia. N. Hydrocele of cord with scroto-inguinal hernia. O. Cyst of the cord independent of any hydrocele and complicated with hernia. P. Spermatocele of cord. Q. Pyocele of cord. R. Hematocele of cord. (See text.)

cord may exist in association with an improperly descended testis. It may be found anywhere along the course of the inguinal canal, or retroperitoneally in the lower abdominal region. Such a hydrocele may exist in the complete absence of a testis or with an undeveloped or atrophic testis. It may contain a tumor of the cord, as in McNeer's case recently observed at the Memorial Hospital in New York, in a man 53 years of age, which I have had the opportunity to see personally. Hydrocele in an undescended testis may exist in association with a hydrocele of the tunica vaginalis propria. The diagnosis, while it may be suspected, is as a rule made only at operation.

Other complications of hydrocele. Other complications, besides hernia, that may accompany hydrocele are rupture of the sac, with the fibrous transformation of the tunica or even its calcification, suppuration of the sac, torsion of the cord, hematocele, spermatocele, lymphocele, varicocele, tumor, and even tuberculosis. All these conditions may be found associated with any of the types of hydrocele discussed in the classification, and should be clinically differentiated before operation. If the condition of hydrocele is of long standing and no treatment is given, atrophy of the testis is bound to occur.

Symptoms. A painless swelling, about the size of an egg or a lemon, may be seen along the line of the cord, gradually increasing in size. If unaccompanied by hydrocele of the tunica vaginalis propria, it may go for a long time without giving discomfort. When it attains a sufficient size, however, there is a dragging sensation. If hernia into the sac has occurred, the characteristic discomfort that attends any hernia will be experienced. In cases not thus complicated there is no tenderness on pressure.

Diagnosis. Uncomplicated congenital funicular hydrocele can be distinguished from congenital hernia by the fact that it is dull on percussion. It is reducible by steady, continuous pressure, gradually applied, without sudden jerk. It can also be known by its translucency, and by absence of gurgling on manipulation.

The infantile type, on the other hand, is wholly irreducible, and does not, like the so-called " congenital " type, vary in size and tenseness according to the position assumed, with elevated scrotum. Like the congenital hydrocele, it is translucent and exhibits no gurgling.

Treatment. The treatment of hydrocele is (1) *palliative* or (2) *radical.*

Palliative treatment of acute cases consists of proper scrotal support, rest in bed, application of an ice bag, and, in appropriate cases, tapping, with aspiration, to relieve tension in the sac of the hydrocele and the painful condition of the scrotum. Since these cases are accompanied by acute epididymitis or traumatic orchitis, or develop as complications of specific fevers or gonorrhea, treatment addressed to the cause of the complication will, as a rule, result in subsidence of the acute condition without any further treatment.

Treatment by needle aspiration. The majority of the hydroceles that come for treatment are of the chronic type. In adults, tapping should be regarded only as a palliative measure, since the sac always has a tendency to refill and there is danger that complications may develop as a result of this kind of interference.

When the sac of the hydrocele does not transilluminate, and the diagnosis is not absolutely certain, tapping or needle aspiration is contraindicated, especially in the congenital type of hydrocele, which may be complicated with the presence of a hernia.

Radical surgical treatment is indicated when the hydrocele continues to enlarge or remains tense, causing a dragging sensation or painful symptoms in the groin or scrotum. Two methods are available, the *closed* and the *open*. The closed method consists of tapping, combined with injection of irritating fluids for closed sacs of hydroceles of the cord or of the tunica vaginalis, when it is certain that no other lesions are present. The second method consists of open operation with eversion and resection of the sac. The differential diagnosis must be made first and always in each case, and the case then be treated according to the pathological conditions present, and on its own merits.

Aspiration and injection. It is true that many authors of our own day still claim excellent results with this closed method of injection; nevertheless, it can not be accepted as a panacea or as free from danger, since failures and complications are frequently observed when it is used. However, this method, which has been in use from prehistoric days, still has numerous adherents, and has been recently revived. Essentially there are 3 varieties of technic in vogue: (1) repeated needle aspiration of the fluid from the hydrocele; (2) closed aspiration followed by injection into the hydrocele of some one of the sclerosing and irritating chemical substances that are in common use, with the hope that the sac will not refill; (3) the same procedure as above, but leaving an open fistulous tract at the point of puncture, with or without a gauze drain (Fig. 52), for the purpose of irrigating the sac of the hydrocele, allowing complete evacuation of its contents and stimulating the formation of adhesions between the tunica albuginea and the tunica vaginalis propria, in an effort to close off the lumen of the

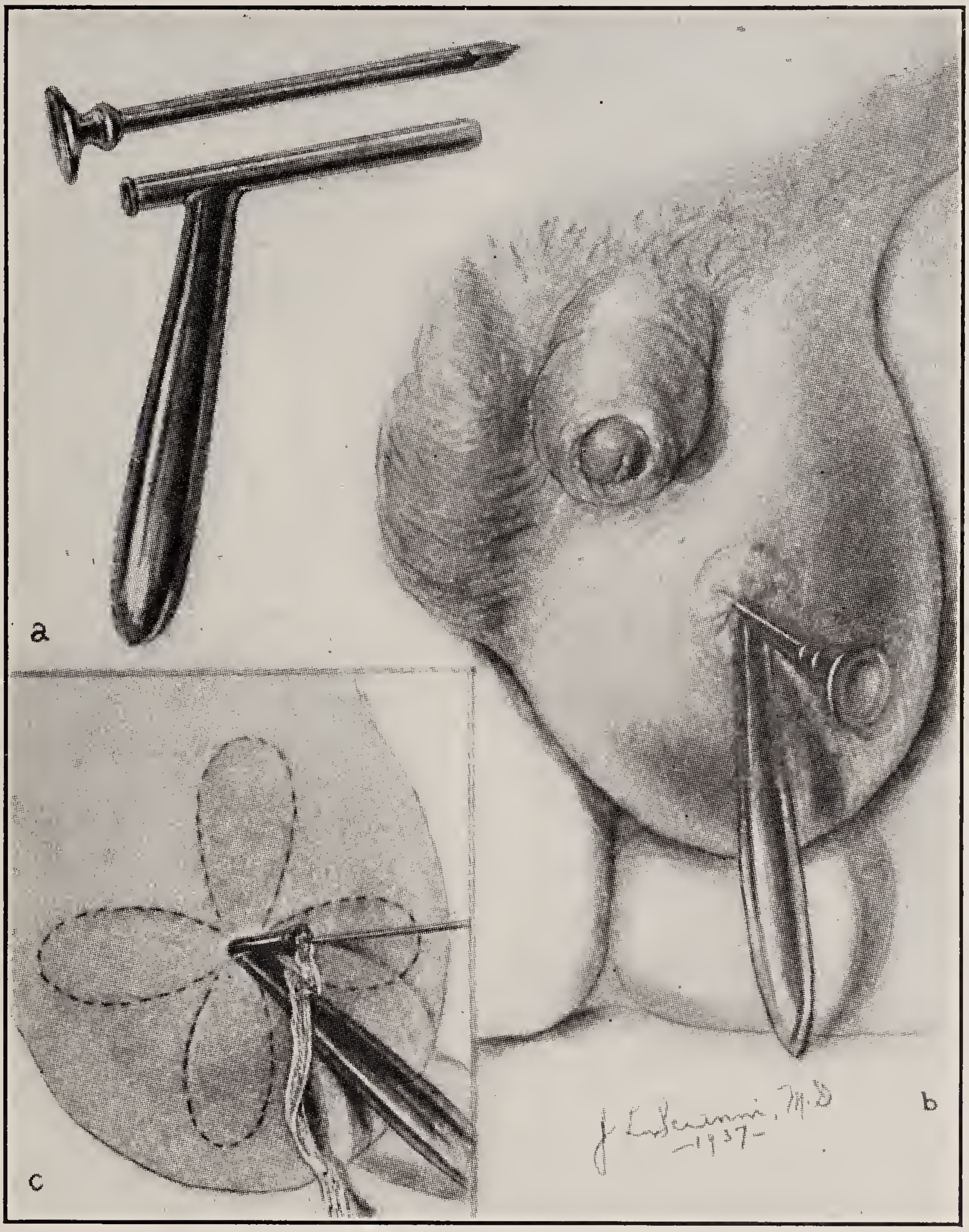


Fig. 52. Closed method of treating hydrocele.
(a) Trocar and cannula employed in aspiration of hydrocele.
(b) The trocar has been introduced into the sac of the hydrocele by puncturing the scrotum at the proper level.
(c) After the sac has been drained, it is packed with a narrow strip of gauze to maintain an open fistulous tract for irrigation and drainage. (After Livermore.)

sac of the vaginalis. This last method has recently been revived by Livermore, of Memphis, who has reported 16 consecutive cases treated, with only 2 failures. On the other hand, the closed method of needle aspiration and injection without drainage has been championed recently by Ewell and his associates, of Madison, Wisconsin. It appears to give satisfactory results in their hands and in those of their followers, since they report that in a follow-up of 165 cases there have been only 7 failures or recurrences. However, some of their patients are still under treatment or have been followed for a few months to 17 years. At any rate, it is evident that this closed procedure is not entirely free from complications, injuries and dangers, and does not yield 100 per cent. of cures.

The most common sclerosing and irritative substances employed for injection in the presurgical days were iodine, bichloride of mercury, formalin, silver nitrate, and carbolic acid. Today, less irritating and less toxic chemical solutions are used, such as quinine, urethane, sodium morrhuate, and the like.

Operative treatment: hydrocelectomy. The radical cure of hydrocele of the cord or of the tunica vaginalis is *hydrocelectomy.* Several procedures are recognized for this open surgical treatment, according to the individual type of case and the associated pathology that may be present at the time of operation. In general, these well-recognized procedures are: (1) opening, draining, and eversion of the sac; (2) eversion and partial resection of the sac.

1. **Simple eversion.** The most classic procedure of olden times was the simple opening and eversion of the tunica vaginalis, the so-called "Andrews bottle operation," which can be performed under local or spinal anesthesia. It consists of making an incision high in the scrotum and dissecting free the various layers that compose the sac; then clamping, opening and everting the sac and placing a continuous suture of chromic catgut along the edges from the bottom of the testis and epididymis all the way up along the cord, in a bottle-shaped figure. The wound is then closed with interrupted silkworm-gut sutures, a cigaret drain left at its lower angle, and the scrotum immobilized by a tight suspensory. While this procedure is simple and effective, it is not applicable in large hydroceles of long standing, where the redundant flap of the everted sac is quite loose; it should, therefore, be trimmed, especially when there is a marked thickening or induration of the wall of the sac, since, if it is not resected, fluid may form again in the loose space left behind, causing recurrence of the hydrocele.

2. **Eversion and resection.** The method of choice, however, and the one that I usually employ, is the Winkelman-Jaboulet operation. In this method the sac of the hydrocele is dissected, exposed and opened as in the previous method, and the tunica of the sac entirely resected around the testis and epididymis, preserving the blood supply of both these structures. Care must be taken in clamping and ligating all the small blood vessels, in order to prevent oozing or possible hemorrhage, which should never occur after operation. The resected edges of the sac are then tied with interrupted sutures all the way around the testis, cord, and epididymis, so that no portion of the wall of the sac will be left behind. In other words, the sac of the hydrocele is entirely excised, accomplishing a complete hydrocelectomy. This procedure should be applied alike in hydrocele of the cord and in that of the tunica vaginalis propria. The wound of the scrotum is closed in the usual manner, leaving a Penrose drain at its lower angle, and a tight suspensory is applied to immobilize and elevate the scrotum.

This radical operation of excising the entire sac of the hydrocele offers, as a rule, a permanent cure. (See Fig. 53, A, B, C, D.)

In dealing with the congenital or the infantile type of hydrocele, particular care must be exercised in dissecting the sac of the hydrocele from the elements of the cord at a point as high as possible, in order to obviate complications and recurrences and to insure the entire removal of the sac, and that no opening of the peritoneum is left behind which might invite hernia. When the hydrocele of the cord is associated with an inguinal hernia, the incision in the groin should be carried higher into the inguinal region in order to expose anatomically and resect the sac of the hernia and reconstruct the abdominal wall, as in an ordinary Bassini hernioplastic operation. This procedure also applies to the bilocular hydroceles, which, when very large, are found located extraperitoneally in the abdomino-inguino-scrotal region.

The treatment of multiple hydroceles of the cord, with or without hydrocele of the tunica vaginalis, involves the same open surgical treatment of opening, draining and resecting all the cysts or hydroceles that may be found in the scrotal content, in order to relieve symptoms and prevent possible atrophy of the testis.

Hydrocele of the canal of Nuck in the female. In passing, it is of interest to note that encysted hydrocele in the male has its counterpart in the female in the encysted tumors that are occasionally found accompanying the round ligaments at the point where

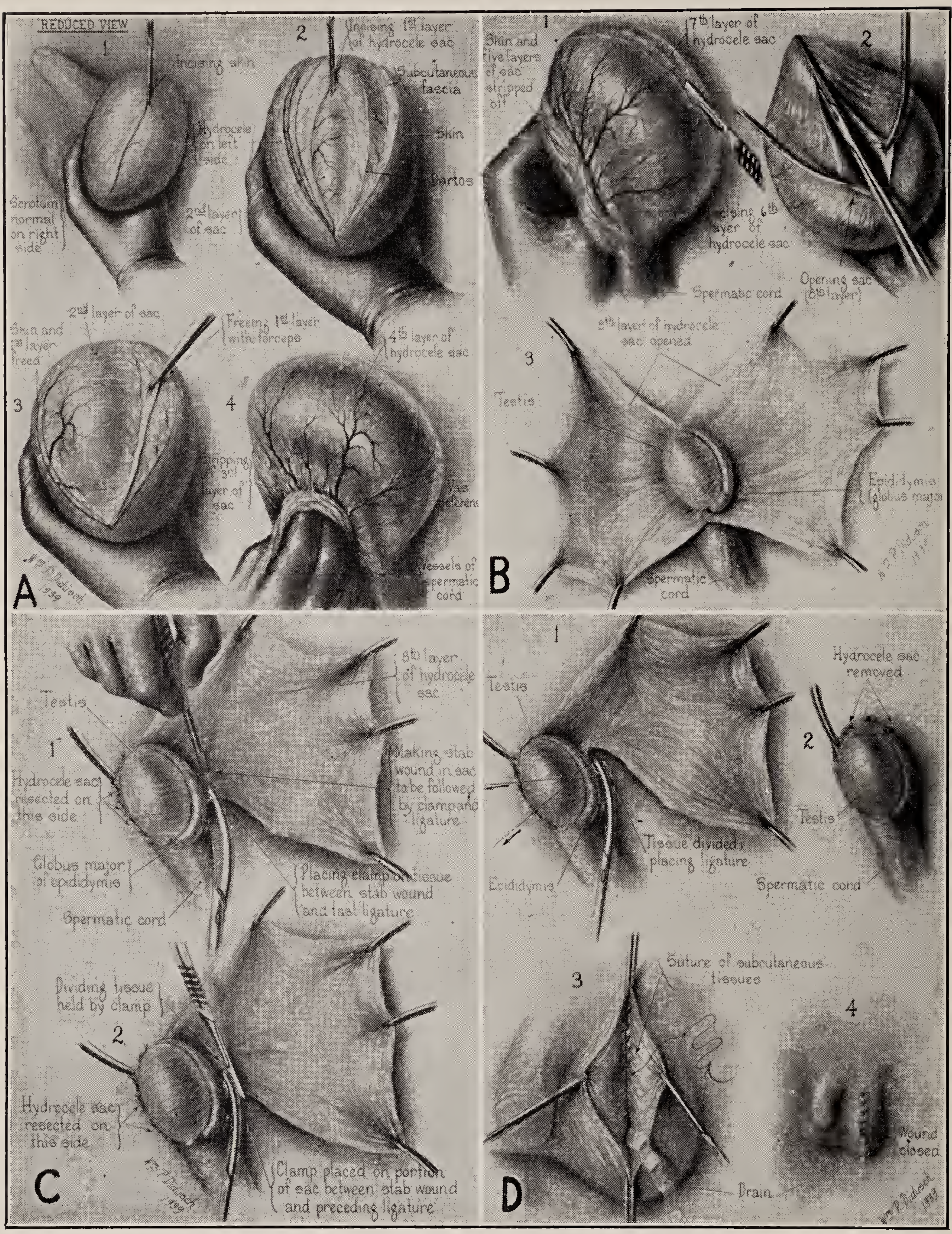

REDUCED VIEW
A
1
Incising skin
Hydrocele on left side
Scrotum normal on right side
2nd layer of sac
2
Incising 1st layer of hydrocele sac
Subcutaneous fascia
Skin
Dartos
3
2nd layer of sac
Skin and 1st layer freed
Freeing 1st layer with forceps
Stripping off 3rd layer of sac
4
4th layer of hydrocele sac
Vas deferens
Vessels of spermatic cord
B
1
Skin and five layers of sac stripped off
7th layer of hydrocele sac
Incising 6th layer of hydrocele sac
Spermatic cord
2
Opening sac (8th layer)
3
8th layer of hydrocele sac opened
Testis
Epididymis (globus major)
Spermatic cord
C
1
Testis
8th layer of hydrocele sac
Making stab wound in sac to be followed by clamp and ligature
Hydrocele sac resected on this side
Globus major of epididymis
Spermatic cord
Placing clamp on tissue between stab wound and last ligature
2
Dividing tissue held by clamp
Hydrocele sac resected on this side
Clamp placed on portion of sac between stab wound and preceding ligature
D
1
Testis
Epididymis
Tissue divided; placing ligature
2
Hydrocele sac removed
Testis
Spermatic cord
3
Suture of subcutaneous tissues
Drain
4
Wound closed

FIG. 53 A, B, C. D. See caption on facing page.

FIG. 53. Operative treatment by hydrocelectomy for radical cure of hydrocele.
A. This group of 4 drawings illustrates the successive steps in exposing and dissecting free the several layers of the sac of the hydrocele.
B. (1 and 2) The final steps are shown in dissecting the innermost layer of the sac of the hydrocele before it is clamped and opened. (3) The sac is clamped and widely opened to expose the testis and epididymis.
C. (1 and 2) The sac of the hydrocele is resected in its totality around the testis and epididymis, with particular care not to interfere with the blood supply of the testis.
D. (1 and 2) The sac has been excised, and interrupted transfixed ligatures have been made all the way around. (3 and 4) The edges of the dartos are approximated with plain catgut and the wound is closed, leaving a small cigaret drain at its lower angle, after which the edges of the skin are brought together by interrupted silk sutures. (Courtesy of Dr. H. H. Young. From Surgery, Gynecology, Obstetrics, **70**: 807, 1940.)

they pass through the inguinal canal. These tumors are formed as the result of an accumulation of fluid in a persisting canal of Nuck, which is the structure in the female corresponding to the processus vaginalis of the peritoneum in the male. Such a cyst may be found at any point in the round ligament, on either side of the pelvis. It does not, however, originate in this ligament, but in the peritoneum, from which it has been shut away just as occurs in the commonest form of hydrocele in the male. But just as in the male, it may also occur in a " congenital " form in a sac of peritoneum that has failed to close and remains with a permanent small opening into that cavity. These female hydroceles may, in fact, assume any one of several forms met with in the male, including the bilocular or hour-glass type and the hydrocele that develops within the sac of a hernia. Coley, in 1908, reported 160 cases of hydrocele of the canal of Nuck encountered at the Hospital for Ruptured and Crippled, in New York City; and other cases of this condition have been recorded by Halstead and Clark, Johnson, Martin and Price. Seventeen cases of Nuck's hydrocele have been reviewed at the Mayo Clinic by Counseller and Black. In 7 of these hernia was present. These authors believe that not over 350 cases of this abnormal condition have ever been reported, thus supporting the view that hydrocele in the female is a rare finding.

SPERMATOCELE

Spermatoceles are retention cysts which contain, or have at some previous time contained, spermatozoa. Although in the great majority of cases they are derived from the seminiferous ducts, and thus develop from the testis or epididymis, spermatoceles are occasionally observed that arise from the spermatic cord. When this occurs, the point of origin is likely to be either in the paradidymis or in the inferior or superior vas aberrans, the vestigial structures that constitute blind tubules at or near the point where the ductus epididymidis becomes the vas deferens.

Pathogenesis. Spermatoceles of the cord are frequently mistaken for hydroceles but their origin is quite different, as is shown by their epithelial lining. They may be intravaginal or extravaginal.

Sometimes a simple cyst, originating in some vestigial structure that has no connection with the seminiferous system, may at a later time effect an opening into some part of this system, and thus become a spermatocele. (Fig. 51–II, P.) A hydrocele also may open into some part of the spermatic tract and likewise become a spermatocele. These two conditions may coexist in the same individual. The size of the spermatocele is usually small but may become very large, even exceeding in size the testis itself. Cases have, in fact, been reported in which the patient thought he had a third testis.

Symptoms. These spermatoceles grow slowly and sometimes give no symptoms. All the patients in Campbell's series of 28 cases complained of swelling and a dragging sensation, and in 10 cases examined for spermatozoa these were present. In most cases fluctuation can be elicited.

Diagnosis. The content of a spermatocele is a milky fluid, mostly with, but sometimes without, spermatozoa. Diagnosis is made by aspiration. Transillumination is not of much value in diagnosis, since there may be translucency even with a milky fluid present.

Treatment. In minor cases of spermatocele, with few symptoms, the treatment is purely conservative, consisting of rest in bed, an ice bag or hot water bag applied to the scrotum, and a suspensory provided to elevate and immobilize the genital organs. This treatment is particularly indicated whenever there is a history of trauma, gonorrheal infection, or chronic epididymitis.

In severe cases, when spermatocele is of long standing and of tumor size, the treatment is surgical. In its simplest form it consists of needle aspiration and injection of a sclerosing substance as in an ordinary hydrocele. Radical treatment, however, calls for open surgical exposure and resection of the sac, no matter where it may be found, whether located inside the tunica vaginalis and arising from the epididymis or paradidymis, or altogether outside of the tunica at some point along the course of the cord. The sac of the spermatocele is freely exposed, separated from its adhesions and its base resected all around, ligated and everted, as in an operation for hydrocele of the cord. The wound is closed with a small cigaret drain and a tight suspensory is applied (Fig. 54, A, B).

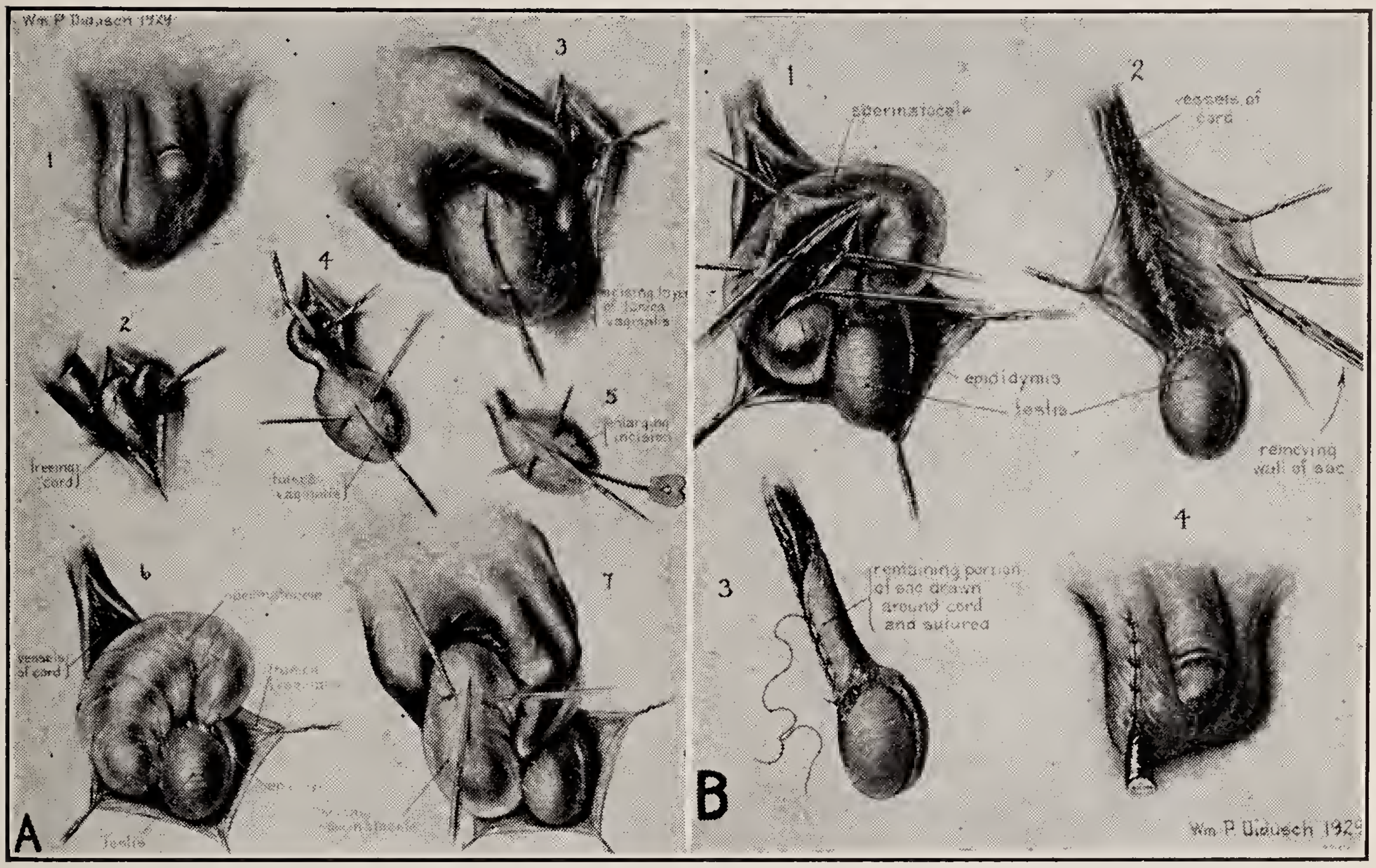


FIG. 54. Drawing to illustrate the surgical excision of a spermatocele.

A. Steps in the technic of the operation. (1 and 2) The incision is made in the scrotum and the cord exposed and freed by blunt dissection.
(3, 4, 5, and 6) The cord with its sac is brought out of the wound and an incision made in the tunica vaginalis, exposing the testis, epididymis, and the sac of the spermatocele.
(7) The spermatocele is clamped and an incision made to evacuate its fluid.

B. Further steps in the technic of excision of a spermatocele.
(1 and 2) The wall of the sac is opened widely and resected without interfering with the blood supply of the testis.
(3 and 4) The remaining portion of the sac is drawn around the cord and sutured, after which the wound is closed by interrupted silkworm-gut sutures, leaving a cigaret drain at its lower angle. (Courtesy of Lowsley and Kirwin, *Clinical Urology*, **1:** 491–492, Williams & Wilkins Co., 1940.)

In some instances of sterility, particularly in younger individuals, when there is stricture of the vas deferens at the globus minor, one may carry out a conservative plastic operation, consisting of anastomosis of the vas to the spermatocele, by Hagner's method, described in a previous chapter on Operations for the Correction of Sterility.

PYOCELE

Just as hydrocele is a collection of fluid in a preëxisting cavity, so is pyocele a collection of pus in such a cavity, as the name implies. Within the scrotum, a pyocele may occur as a complication of some other localized suppurative infection inside the scrotal sac, such as funiculitis, vasitis, or orchitis, epididymo-orchitis, or even abscess of the testis or epididymis. Pus may be found within the tunica of the cord or that of the testis, after some operation in which there has not been complete asepsis. Sepsis may reach the scrotal sac from an infected prostate or seminal vesicle, after an operation on the prostate. Pyocele is by no means unusual within the tunica vaginalis as the result of extravasation of infected urine into the scrotal tissues in cases of urethral traumatic rupture or diverticulæ. Pus may form simultaneously in the cord and the tunica vaginalis; or a hematocele that has formed may be converted by suppuration into a pyocele (Fig. 51–II, Q). When this occurs, treatment consists in free incision and clearing out of the sac, followed by drainage.

LYMPHOCELE (CHYLOCELE)

An obstruction may occur in the lymphatics that accompany the pampiniform plexus within the cord, resulting in a collection of fluid resembling milk or chyle within the tunica vaginalis communis. The lymph, leaking through the walls of the dilated vessels, accumulates and forms a sac in the cord or tunica vaginalis, known as a lymphocele. Owing to the resemblance of the fluid to chyle the name of chylocele was formerly given to such a sac, which was erroneously believed to contain chyle. The commonest cause of a lymphocele is filariasis, which is due to the presence of filariæ in the blood. For a discussion of filariasis of the cord, not infrequent in tropical countries, and its relation to elephantiasis, the reader is referred to Chapter VI on Surgical Affections of the Vasa Deferentia. When filariæ are absent, the obstruction of the lymphatics may be attributed to some other inflammatory process that has affected the glands and lymphatics of the cord. Such inflammation may be due to trauma or to fatty degenerative changes in the epithelium of the tunica of the cord and the fluid of a common hydrocele. Examination of the contents reveals the presence of fat. Occasionally lymphocele may form simultaneously in both sides of the scrotum.

The symptoms are those of any ordinary hydrocele.

The diagnosis is made on the absence of the translucency of the ordinary hydrocele, since the milky fluid content renders the lymphocele less pervious to light.

Treatment consists of incision and resection of the sac, with ligature of any leaking lymphatics that may be found. If the condition is accompanied by varicocele, the anterior group of veins of the pampiniform plexus should also be resected. It is imperative that the patient wear a suspensory and that the constitutional cause of the disease be treated.

HEMATOCELE OF THE SPERMATIC CORD

Etiology. When blood collects in the sac of a hydrocele we have a hematocele. This is usually the result of traumatism, but may be due to spontaneous rupture in the rich, delicate pampiniform plexus of veins or in an artery supplying the testis or epididymis. It may also be incidental to a malignant growth. Traumatic hematocele may follow any kind of blow, kick, or sudden impact that ruptures a vessel of a hydrocele or spermatocele already in existence. A hematocele differs from a hematoma in that it is a preformed sac containing a blood clot, and not simply a collection of blood that has escaped into tissues adjoining a ruptured blood vessel. It may or may not be associated with a hematoma. Hematoma, as a rule, is a complication observed as the result of poorly executed operations upon the contents of the scrotum. When there is oozing, or when a vessel has not been properly tied, in a case where no drainage has been provided, a hematoma of some considerable size is certainly bound to form.

Hematoceles may occur in all the different types of hydroceles, whether vaginal, congenital, infantile, or inguinal, bilocular or unilocular; and there may even be a hematocele of a hernial sac, or of a spermatocele, which then becomes a hemato-spermatocele. A frequent cause of bleeding is the puncture of a vessel during an unskilful aspiration of the fluid in a hydrocele; this is particularly true when the hydrocele is within the tunica vaginalis propria of the testis.

Pathology. The bleeding may be intravaginal or extravaginal, or both. Presence of blood within the sac causes a gradual thickening of the enveloping tunica, which may involve the entire testis and cord, as the tunica becomes fibrotic or even calcified. Large hematoceles cause atrophy of the testis and of the cord elements as the result of long-continued pressure upon these organs. The content of the sac is a clot which becomes liquefied at the center, while the portion at the periphery becomes a semi-organized fibrinous mass (Fig. 51–II, R).

In certain cases in which the blood is not resorbed, the clots may disintegrate and infection set in with abscess formation. If the condition is of long standing, it may become chronic, with development of *pachyvaginalitis* and calcification of the tunica of the sac.

Symptomatology. The bleeding may be rapid or slow, and the same is true of the formation of the hematocele. A rapid escape of blood into the sac of the hydrocele will be accompanied by great pain in the groin and a sense of prostration; the sac becomes swollen, and if the hemorrhage into it is extensive, the tunica may itself be ruptured, with escape of blood into the cellular tissues of the scrotum, causing the overlying skin to become first reddened and edematous, then, after a few days, blue or purplish as in other forms of contusion. In some cases, if it is not properly opened and drained, gangrene develops; the individual then becomes septic and general constitutional symptoms appear.

Diagnosis. A hematocele is readily differentiated from a hydrocele by its opacity upon transillumination, by the history and the rapidity with which it develops, the firmness of its consistency, and the changed color of the skin of the scrotum. Hematocele of the cord is difficult to differentiate from a strangulated hernia or neoplasm. Hematocele of the tunica vaginalis is readily recognized by tapping of blood from the vaginal sac. The physical appearance of a tunica engorged with blood is that of a tender, opaque mass within the scrotum, with smooth, rounded outline. When differentiation from a tumor is clinically impossible a plain roentgenogram will, in all long-standing cases with thickening and calcification of the walls of the sac, disclose the presence of pachyvaginalitis and will orient the diagnosis toward an old chronic hematocele.

Treatment. In cases where the hematocele is recently formed, rest in bed, with a suspensory and ice bag applied to the scrotum, may be enough to control the bleeding. If, however, the mass continues to increase in size, one should make an attempt to aspirate the blood from the sac by means of a large-sized trocar and cannula, under aseptic precautions. If this fails to reduce the size of the mass, a simple opening and drainage of the sac with ligature of the bleeding points may suffice to save the testis. The scrotum should then be immobilized and elevated with a Bellevue bridge suspensory. In more advanced cases, the fibrotic and calcified tunics of the sac must be resected. The wound in the scrotum is then closed with interrupted silkworm-gut sutures, leaving a good-sized Penrose drain at its lower angle. This wound should be dressed daily. In some cases that are complicated with multiple abscesses, it should be kept wide open, packed with iodoform gauze, and irrigated daily with mild antiseptic solutions until it heals by granulation. In this way, it may still be possible for the testis to be saved. When the testis has been completely destroyed by long pressure, however, orchidectomy with high resection of the cord is the only resort.

CYSTS OF THE CORD

In dealing with any smooth globular tumefaction along the spermatic cord in which a tumor and all varieties of hydrocele can be excluded, one must think of the possibility of a cystic formation, congenital or acquired, simple or of parasitic origin (Fig. 51–II, O).

A simple cyst (**retention cyst**) may be formed anywhere in the region of the cord, due to a traumatic lesion inflicted upon the pampiniform plexus of veins or upon the lymphatics, or to chronic inflammation of the tunica vaginalis or the membranes of the cord proper. When such a lesion exists and is attended with an extravasation of blood, lymph or exudates, it may give rise to a cavity which, if not resorbed, will result later in a cystic formation.

Cysts arising from embryonal rests within the cord. Such cysts develop from the lumen of the vas deferens, and their anatomotopographic relationship is shown in Figure 50.

Dermoid cysts may also be found in the cord. These are discussed in the section on Tumors of the Cord.

Echinococcus cysts developing within the cord are due to the same etiological agents which produce parasitic cysts elsewhere in the body, reaching the cord through infestation of the blood stream. While these cysts are commonly found in the lungs, liver, and kidneys, it is relatively rare to find them in the spermatic tract.

Any type of cyst of the spermatic cord may be found associated with any other pathologic condition of the cord, such as tumor, hydrocele, or inguinal hernia (Fig. 51–II, O).

Diagnosis of cysts of the cord, whether simple or parasitic, is difficult. As a rule cysts do not transilluminate. When the cyst is large, thick, and indurated, the differential diagnosis from tumor of the cord can only be made by needle aspiration, biopsy, or at operation.

The differential diagnosis of echinococcus cyst is made if the ova or the hooklets of the larvæ are found in the fluid content of the cyst, or if daughter cysts are discovered in the specimen removed at operation.

Treatment is surgical. It consists in removal of the cyst and in preservation of the function of the testis.

FUNICULITIS

Whenever any organ contiguous to the cord, or sharing its blood or lymphatic supply, becomes infected, it is possible for the process to pass over into the cord, setting up a *funiculitis*. Nothing is commoner than for a suppurative process in the epididymis or urethra to find its way through the lymphatic vessels into the funicular tissues, where it may involve the pampiniform plexus and even cause an infective thrombophlebitis. Such infection is overwhelmingly the result of gonococcus invasion, but may be due to streptococcus, staphylococcus, or other microbial agent. According to Wehner, the arteries play almost no rôle in the spread of infection from the urethra to the cord. It is probable that the lymphatics participate in the process, but the major rôle appears to be played by the ejaculatory duct and the vas deferens, which transmit the infection directly through their canals to the cord and epididymis. But, since the cord carries the lymphatics and veins of the testis, epididymis, and tunica vaginalis, it can be readily understood that infection may travel to the pampiniform plexus from one of these sources. The infection may also be carried through the sheath of the vas deferens from suppurative lesions of the prostate and seminal vesicles to the epididymis, readily causing a funiculo-vaso-epididymitis. A suppurative process reaching the cord may in some cases even result in abscess formation throughout its entire length.

O'Crowley reported a case in which an acute suppurative process due to staphylococci passed into the cord from a gangrenous appendix, which had been removed some 5 weeks previously, with apparent recovery. The suppuration had, however, continued to burrow its way into the scrotum, and had caused so much destruction of the cord by the time it gave symptoms that the testis could not be saved. The vas deferens, although surrounded by extensive suppuration and necrosis, did not share in the inflammation, and the spermatic arteries were also intact.

Diagnosis. Acute funiculitis must be differentiated from abscess in a hernial sac, abscess of the abdominal wall, abscess associated with appendicitis, hematoma of the cord, venous thrombosis, tuberculosis, syphilis or tumor of the cord, psoas abscess, torsion of the cord, inguinal adenitis, an inflamed undescended testis, and osteomyelitis of the pubic bone. This differential diagnosis is sometimes difficult, since funiculitis and deferentitis may be associated with other lesions, and this cord inflammation may be only a secondary process from a primary lesion such as acute or chronic seminal vesiculitis.

The extreme vascularity of the cord, and its abundant lymphatic supply make it a ready prey to infection from contiguous or neighboring organs. A traumatism inflicted upon any organ within the scrotum may likewise result in funiculitis and deferentitis, which may lead to very grave results if not given proper surgical care. The vas may or may not share in the inflammatory process of the cord.

When infection reaches the pampiniform plexus of veins, the danger of an occlusive thrombosis and infarct is imminent.

THROMBOANGIITIS OBLITERANS OF THE CORD

Definition. This condition, also known as Buerger's disease, consists in an occlusive thrombotic process involving the arteries of the cord and the pampiniform plexus of veins, resulting in their spontaneous gangrene to the extent that they are obstructed. It is a rare condition, when observed in the cord, and one that has received comparatively little attention in the literature. Among those who have discussed it may be mentioned Buerger, who first individualized it in the limbs and later in the cord, McGregor and

Simson, Tartakoff and Hazard, Ercole and his coworkers, Rabinowitz, Oppel, Dmitrijew, Letullé, and Mathé.

Etiology. Various theories have been suggested to account for the thrombotic occlusion within these cord structures. Buerger himself thought that all cases of thromboangiitis obliterans begin in the form of an acute inflammation, but he was not able to find the causal agent. It is generally agreed that an infectious, toxic, or traumatic lesion in the wall of a vein must underlie the appearance of the syndrome wherever localized. The physico-chemical condition of the blood is believed to play an important part. Some authors have suggested that an overproduction of platelets, such as was actually observed in Ercole's case, is related to its development. Oppel and also Dmitrijew thought that hyperactivity of the adrenals was a factor, causing too great an amount of vasoconstrictor substances within the blood. Letullé and his coworkers attributed the thrombotic condition to an unknown infectious organism, resembling that of leprosy, syphilis, or tuberculosis. Rabinowitz actually thought he had isolated the responsible microörganism. No such organism, however, has as yet been confirmed, and the etiology remains in the field of hypothesis alone. All that we know is that the basic condition for production of any thrombosis of angio-obliterating type is the presence of a lesion within the wall of a vein or artery; but whether this is due to infection, causing thrombosclerosis, to toxins, to trauma, or to a combination of these, remains unknown.

Symptomatology. The first symptoms to be observed are swelling and tenderness in the groin of the side affected, with dull pain and a dragging sensation, extending downward to the testis. Systematic symptoms may be entirely absent. These dull pains may radiate to the penis and to the lower abdominal wall. The clinical appearance is almost exactly the same as in cases of tuberculous epididymitis. There is a positive von Pirquet. Nodules appear in the epididymis which are in no way distinguishable from tuberculous nodules. In McGregor and Simson's case at St. Bartholomew's Hospital, London, it was thought that no case could mimic tuberculous epididymitis so closely as did this one. The nodules do not resemble those of gonorrhea. There may also be seen numerous tortuous veins of a purplish-red color coursing through the skin of the scrotum, presenting the characteristic engorged and swollen appearance of phlebitis throughout the entire cord up to the external inguinal ring.

Pathology. The early stage consists of an inflammatory lesion, which presents a typical morphological picture while in the process of healing. At this time purulent foci appear, but examination has revealed no microörganisms, even in this acute stage of inflammation. An outstanding finding is apparent thickening of the upper end of the vas deferens. An occlusive thrombotic process involves the mass of veins composing the pampiniform plexus. It is this venous thrombotic mass which proves to be the cause of thickening within the cord, unaccompanied by any thickening of the vas itself, which remains normal within the cord. The thickened vessels adhere so strongly to the vas as to seem a part of it.

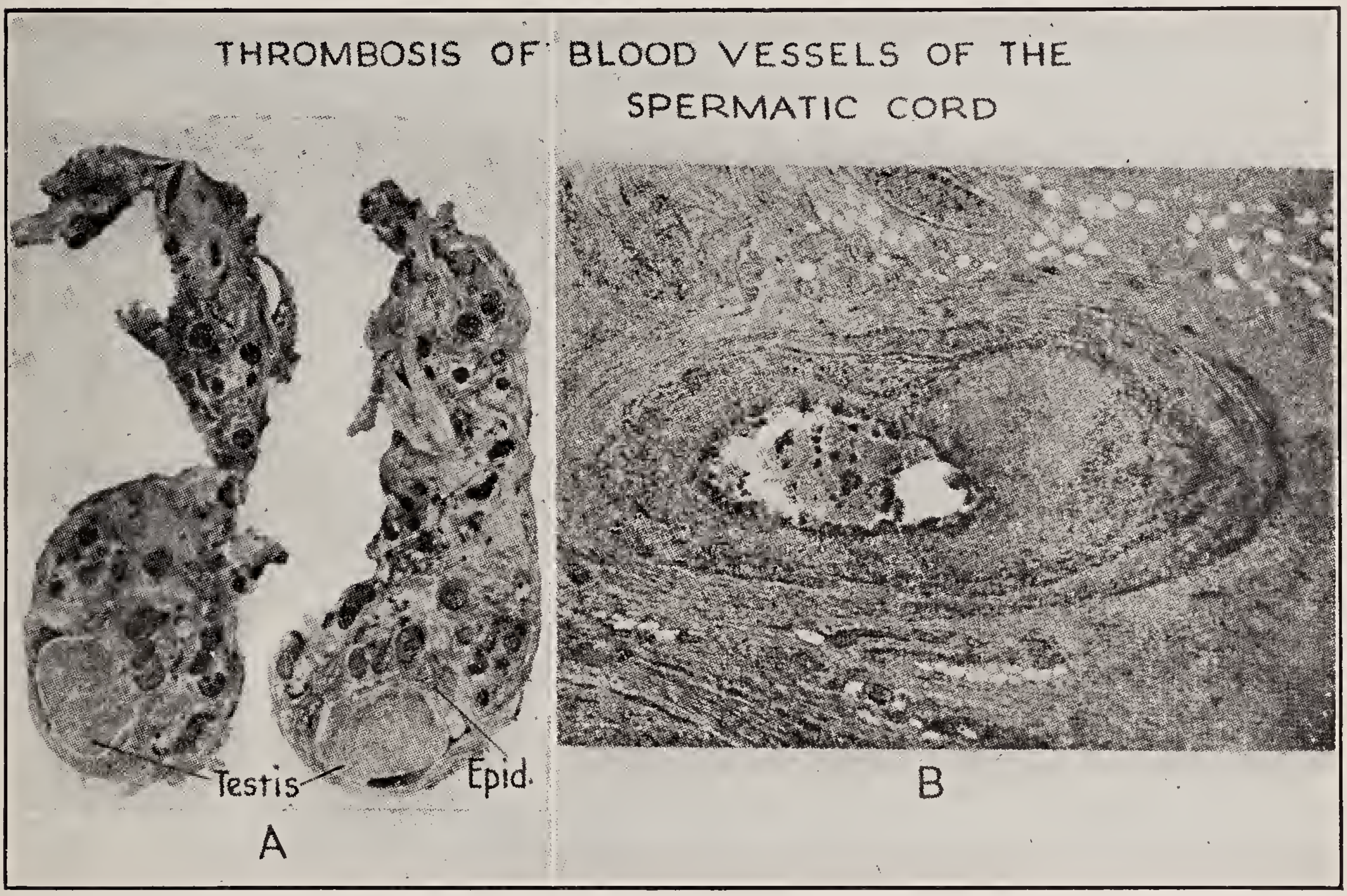


Fig. 55. Thromboangiitis obliterans of the spermatic cord. (Ercole's case.)

A. Photograph of specimen removed at operation by left orchido-epididymectomy, showing the marked thickening of the cord, with occlusive thrombosis of the masses of the pampiniform plexus and atrophy of testis and epididymis.

B. Low-power photomicrograph of a histological section of cord, showing the thrombotic process occluding the lumen of a vessel.

The sequence pathologically appears to be: acute inflammatory infiltration of the vessels and their supporting tissues; occlusive thrombosis; formation of purulent foci, especially within the peripheral part of the coagulum, foci of giant cells replacing those of leukocytes, and a matting together of all the arteries, veins and nerves due to an inflammatory fibrosis, associated with the organization and canalization of the occluding mass. In Ercole's case, there were vascular lesions that long antedated the beginning of the present disease, since some veins showed proliferations of the intima of polypous type. The veins habitually show more changes than the arteries, though both types of vessels participate. The acute manifestations are found macroscopically in the veins alone (Fig. 55, A, B).

Diagnosis. While these cases appear clinically almost identical with tuberculous epididymitis, the diagnosis is oriented toward thromboangiitis obliterans by the presence of local and radiating pains, associated with the appearance of thickening of the *upper* part of the vas (apparent only), this phenomenon distinguishing them from cases of tuberculosis, in which the thickening is at the lower end of the vas. As has already been pointed out, the vas, in fact, is not thickened or changed, and the apparent thickening is all due to the engorgement of the surrounding vessels. The presence of subjective nagging pains also excludes tuberculosis. The type of nodule present is unlike that of gonorrhea. In reaching a diagnosis, the surgeon should always bear in mind the possibility of an occlusive thromboangiitis obliterans. Hormone tests may exclude tumor of the testis. The presence of undue amounts of adrenalin in Buerger's disease also points toward the correct diagnosis.

Treatment. Orchidectomy is the treatment of choice, since the disease as a rule is progressive. The degree of pain suffered by the patient seems to justify radical operation in most cases. However, the state of the testis should be taken into account, and in cases where it is normal (as in Ercole's case), more conservative treatment may be permissible, always bearing in mind that thrombosis may continue its evolution if the radical operation is not performed.

SOLID TUMORS OF THE SPERMATIC CORD

Solid tumors of the spermatic cord, although a rare finding, have received considerable attention in the literature.

Classification and incidence. The classification usually followed is that of Hinman and Gibson, and is as follows:

Tumors of the spermatic cord:

1. Benign:
    - A. Epithelial (none of these recorded)
    - B. Mesoblastic:
        - (a) Lipoma
        - (b) Fibroma
        - (c) Myxoma
        - (d) Leiomyoma
        - (e) Lymphangioma
    - C. Heterologous tumors
        - (a) Cystic dermoid
2. Malignant
    - A. Epithelial (no authentic case)
    - B. Mesoblastic
        - (a) Sarcoma
        - (b) Myxosarcoma
        - (c) Chondrosarcoma
        - (d) Fibrosarcoma
        - (e) Spindle-cell sarcoma, etc.
    - C. Heterologous tumors
        - (a) Teratoma (including seminoma of Chevassu)

As may be seen at a glance, no epithelial tumors, either benign or malignant, have ever been found primarily in the spermatic cord. Numerous authors have reviewed the literature of solid cord tumors, notable among whom are Tédenat and Martin (1908), Patel and Chalier, (1909), Hinman and Gibson (1924), Rubaschow (1926), MacKenzie (1932), and Thompson (1936). Thompson added 26 cases from the Mayo Clinic to 216 cases already on record, bringing the total to 242.

Since Thompson's paper was published, 18 additional cases have been placed on record. These include those of: Rolando, 1 unclassified solid tumor of the cord (1936); Isnardi, 1 lipoma (1936); Quinby, 2 cases, 1 lipomyxofibrosarcoma and 1 fibrosarcoma (1937); Podetti, 1 fibroma and 1 lipoma (1937); Harkink, 1 myofibroma (1937); Delannoy and Demarez, 1 dermoid cyst (1937); Wolbarst, 1 myxofibroma (1937); Baiocchi, 1 fibromyxoma (1938); Miyagi, 1 fibromyxosarcoma (1938); Burlamaqui Benchimol, 1 lipoma (1939); Suarrez Aguirre, leiomyoma (1939); Dreyfuss and Lubarsch, 1 lipo-osteofibrosarcoma (1940); Scalfi, 1 sarcoma (1940); Graves, Kickham and Buddington, 1 teratoma (1940); Neal and Jolley, 1 fibromyxolipoma (1941); Lo Re, 1 dermoid cyst (1941); Dimitriu and Vasiliu, 1 fibrosarcoma (1941);

and Gräflin, 1 sarcoma (1941) — thus bringing the total of recorded cases to 260, of which about 70 per cent. are benign.

In addition to these recorded cases, I have found in the literature another case of sarcoma of the cord reported by G. C. Burr, of Grace Hospital, Detroit, in 1934, which is illustrated in Figure 56, A, B.

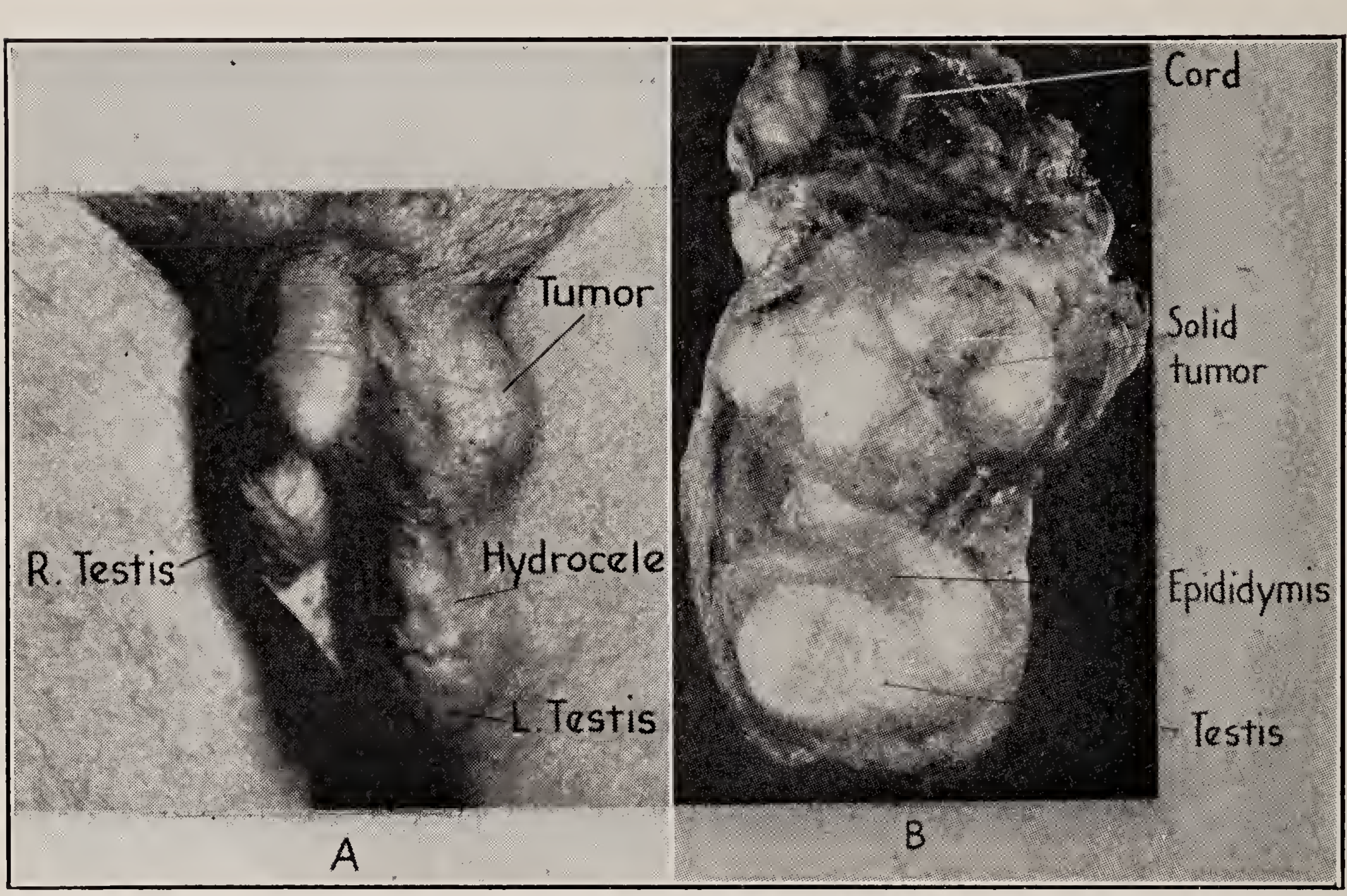


Fig. 56. Solid Tumors of the Cord.

A. Photograph of an actual case of sarcoma of the spermatic cord, showing a primary malignant tumor in the left side of the scrotum of a patient 48 years of age, below which is seen a hydrocele of the tunica vaginalis, with a normal left testis. The right side of the scrotum is shorter and also contains a normal testis.

B. The specimen removed at operation, showing a solid tumor of the spermatic cord, which on histological section proved to be a sarcoma. Below it are a normal epididymis and testis. (Burr, Grace Hospital Bull., Detroit, Vol. 18, 1934.)

I have recently had the opportunity to observe personally 2 more cases which have not yet been reported. The first is that of Dr. G. McNeer, of Memorial Hospital, New York City, in a man of middle age, in whom a fibromyxosarcoma, extraperitoneally located, was discovered in the cord of an undescended testis during the course of a laparotomy operation. The second is the case of a

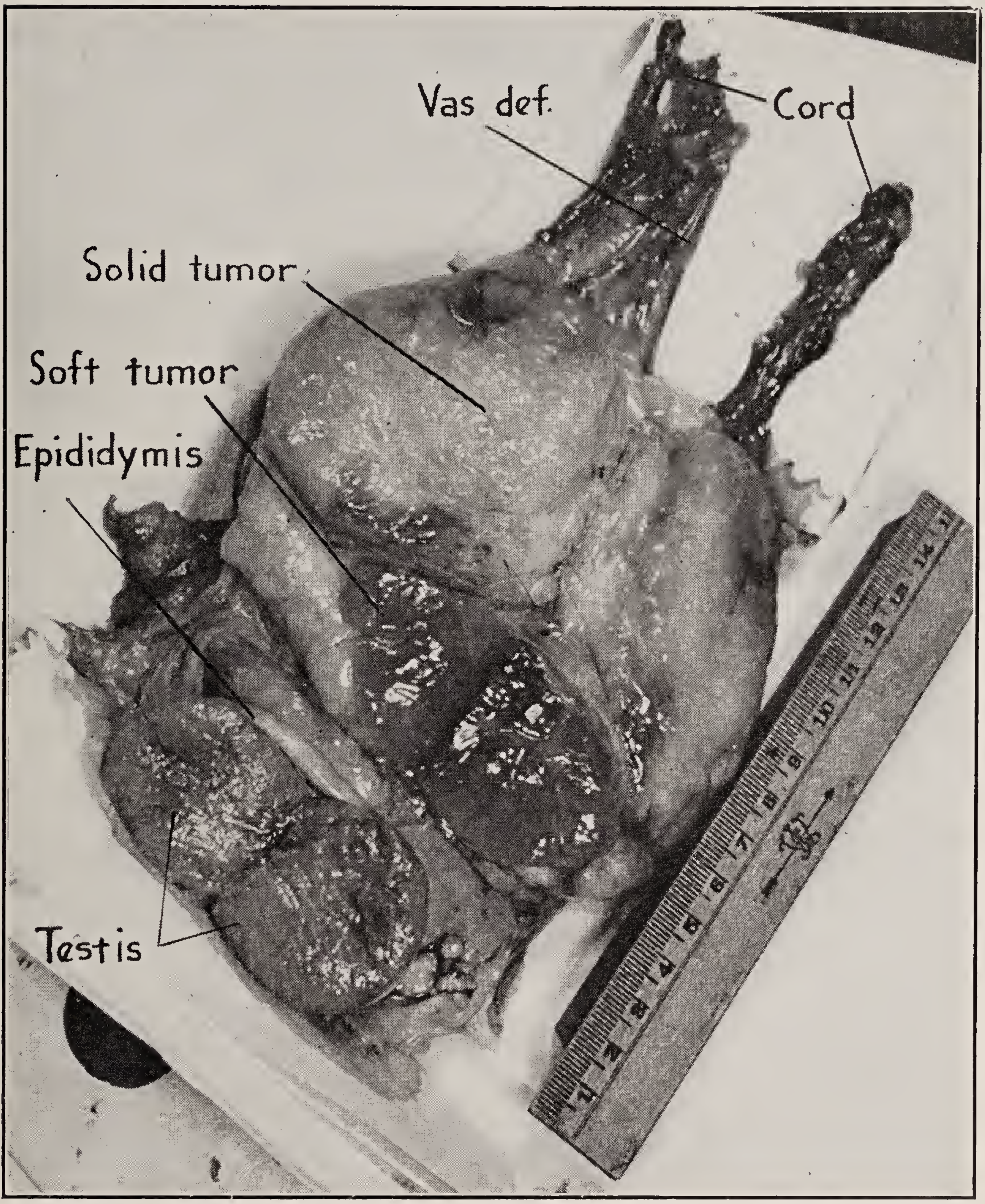


FIG. 57. Operative specimen of a solid benign tumor of the left spermatic cord, complicated with hydrocele of the tunica vaginalis, diagnosed before operation in a man 60 years of age.

The photograph of the specimen removed and laid open shows the upper half of the mass to be composed of a solid tumor of the cord, while its lower portion is of soft consistency. The left testis and epididymis were separated from the tumor by the tunica vaginalis of the hydrocele and were normal. Histological section of the tumor revealed the presence of a fibromyxolipoma. (Courtesy of Dr. A. R. Stevens, Urological Service of the New York Hospital and Cornell Medical College, March 1942.)

man admitted to Dr. A. R. Stevens' Urological Service, in the New York Hospital and Cornell University Medical College, in March, 1942, with a slightly painful swelling on the left side of the scrotum, which had existed for 18 months in an otherwise perfectly healthy individual. On examination, a hydrocele of the tunica vaginalis was discovered, and above it an indurated mass which suggested a tumor of the spermatic cord. The mass was removed with the testis, epididymis and vas, up to the external inguinal ring. The operative specimen, which is shown in Figure 57, proved on histological examination to be a fibromyxolipoma of the cord, located outside of and above the tunica vaginalis propria and showing a perfectly normal testis and epididymis.

Adding these 3 new cases to the tabulated cases of tumors of the spermatic cord, we reach a grand total of 263 cases of tumor of the cord.

The largest group among these benign tumors is that of the lipomas, with fibromas ranking second numerically. It will be observed that most of the benign solid tumors of the cord that have been reported have been of mixed origin, containing fatty, fibrous, muscular, tendinous, or mucoid elements in varying proportions.

Among malignant tumors of the cord, sarcoma is almost exclusively found, to which must be added a small number of cystic dermoids and teratomas, among which is included seminoma (Chevassu).

The average age was 40 to 50 in the majority of tumor patients. Benign tumors of the cord grow slowly, often having a history covering 10 to 15 years.

Among the benign tumors, there is occasionally a history of trauma. In many the presence of chronic inflammation has been held to play a part.

The tumors have been unilateral in all but 3 cases reported. They are more frequent on the left side, and this is especially the case in lipoma. The tumor may extend upward into the inguinal canal, downward into the scrotum in close association with the other scrotal organs. The size attained by these tumors is sometimes enormous. In one of Quinby's cases, the specimen, which had been growing for 10 years, weighed 6540 gm. (nearly 14½ lb.).

Symptomatology. In most of these cases there are for a long time no symptoms of any kind. As the tumor increases in size, its weight drags upon the inguino-scrotal structures, causing pains to dart through the inguinal canal. Only in the late stages of the malignant group, after metastases have occurred, does the patient lose weight and complain of loss of strength.

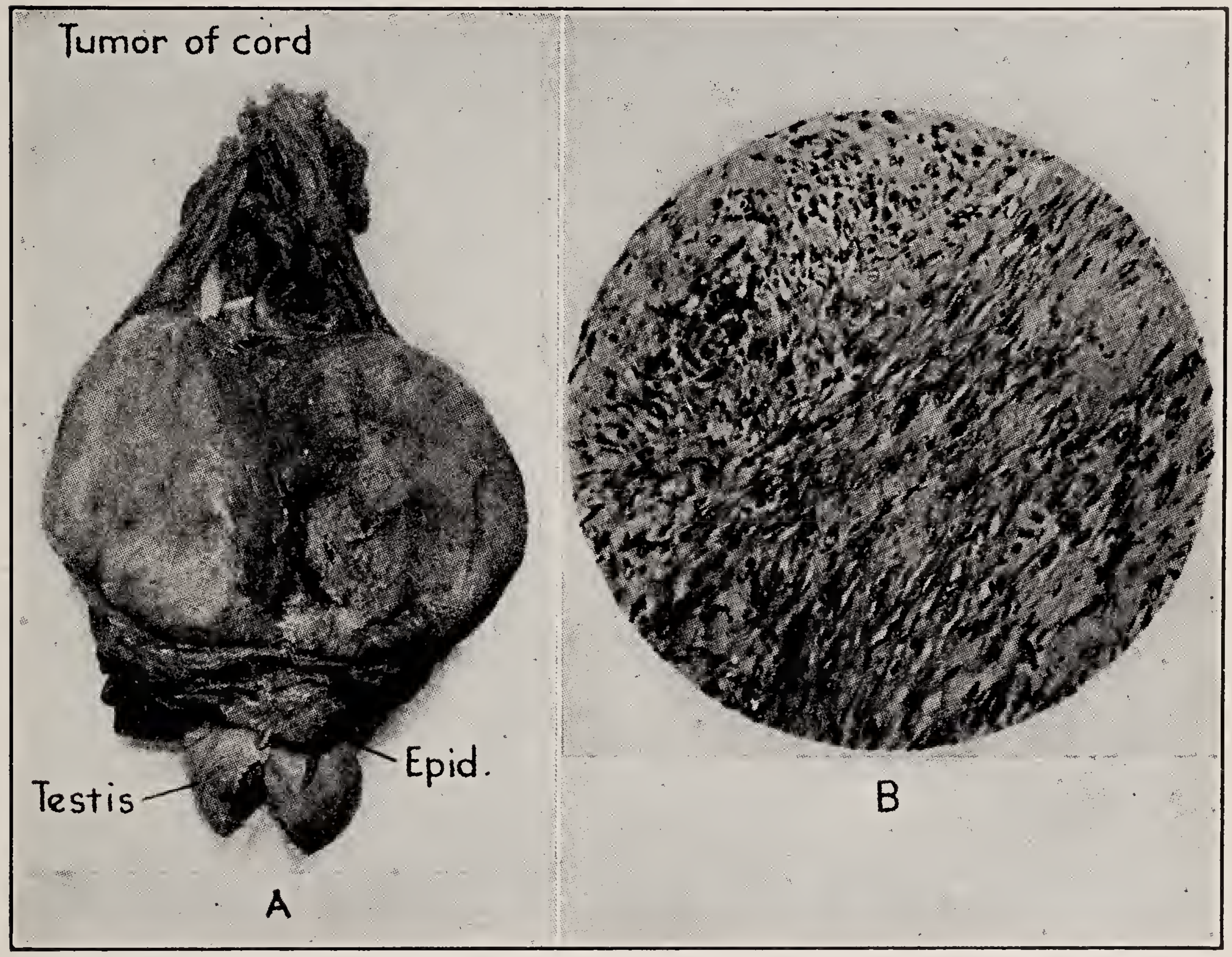


FIG. 58. Photograph of a malignant tumor of the cord removed at operation from the left side of the scrotum of a man 67 years of age.

A. The specimen is laid open, showing a solid tumor of the cord about the size of an orange. Below are seen the normal testis and epididymis.
B. Photomicrograph of a histological section of this tumor, revealing the malignant proliferation of a fibromyxosarcoma of a spermatic cord. (MacKenzie's case.)

Diagnosis may be difficult, and is frequently possible only at operation. A cord neoplasm in the inguinal canal may simulate hernia, hydrocele of the cord, or a cyst of the cord. If the tumor is within the scrotum, differentiation must be made from a number of other scrotal affections, such as tumor of the testis, hydrocele, hematocele, chylocele, spermatocele, hernia, tuberculosis and syphilis. A positive Wassermann does not exclude tumor, since tumor and syphilis may coexist. A doubtful case with a positive Wassermann should be given a course of antiluetic treatment: if the mass becomes less, the diagnosis points to syphilis; if it continues stationary or increases, syphilis is excluded.

Treatment is surgical. It consists of scrotal exposure of the tumor and resection of the cord up to a point corresponding to the external inguinal ring carrying with it the testis and epididymis (Fig. 58). Conservative surgery, in an effort to save the testis and epididymis, does not seem applicable in a case where a diagnosis of potential malignant tumor of the cord has been made, and where the blood supply has been greatly compromised by the extension of the solid tumor. Orchidectomy is therefore imperative, particularly since only one cord is involved. Any more radical procedure does not seem to be indicated unless we are dealing with a case of teratoma testis and not simply a circumscribed primary tumor of the cord, which in most instances will not metastasize. However, in cases in which the tumor has expanded beyond its own capsule, or in which there are already demonstrable metastases elsewhere in the body, castration with high resection of the cord should always be carried out, followed by several courses of roentgen-ray treatment.

Prognosis. Tumors of the cord, as well as those of the epididymis and the tunica of the cord and testis, have a more favorable prognosis than those of the testis itself, which exhibit a high degree of malignancy. The benign cord tumors grow very slowly and may reach an enormous size without producing constitutional disturbances. One should remember, however, that all such tumors may take on a malignant character in their late stages.

In mixed tumors which are in part sarcomatous, the prognosis will depend on the relative proportion of sarcomatous elements present. If the proportion of such elements is small, these tumors not infrequently remain practically benign for an indefinite period. Nevertheless, they should be removed because of their potential malignancy, the pain and discomfort caused by their weight, and the ultimate dysfunction and atrophy of the testis that will result.

FILARIASIS OF THE CORD

Definition. Filariasis is a disease due to infection with the *Filaria sanguinis hominis*, or *Filaria Bancrofti*, which has a specific tendency to find its way to the spermatic cord and the head of the epididymis. The disease is commonly observed in tropical countries. During the last two decades the literature has been enriched by a number of valuable contributions on this subject (Cerqua, Sorour, Ouizellan, Watenabe, Sharp, Ferrer, Rodhain, Young, and others).

Etiology. The filaria worms are found in the scrotum within the lymphatics along the elements of the cord. Here they cause hard, indurated masses that block the lumens of the lymphatics. In many instances the lymphangitis and perilymphangitis extend upward to the inguinal glands, where they produce lymphadenitis. They may also cause thrombophlebitis, with enlargement of the varicosed veins of the scrotum. The vasa deferentia, testes, and epididymes are not involved except in advanced cases, in which the globus major and minor may become nodular, resembling tuberculous epididymitis. The filaria is always found upon histological section of the walls of the organs it has invaded.

Course of clinical symptoms. It is commonly observed that a hydrocele of intermittent type is formed periodically in accordance with the cyclical parturition of the female worm. At such periods, innumerable microfilariæ are found in the fluid of this hydrocele, associated with slight pain along the line of the cord, up to the inguinal ring, and with a distended and shiny appearance of the scrotum. After a period varying from 2 or 3 days to a week, the tumor will begin to diminish, but shows a progressive tendency to enlarge gradually from one such period to another, finally resulting in a permanent hydrocele with progressive thickening of the cord as its ultimate stage. The cord loses its palpability and finally is lost in the edematous tissues of the scrotal pouch.

Diagnosis. The hydrocele of filariasis is characterized by lack of uniformity in the tension of the fluid, which varies with the thickness of the scrotum at different points. One can judge the transparency of the hydrocele by transillumination, since there may be a marked lymphedema of the scrotum, giving a false impression of translucency. There is a progressive thickening of the cord, predominantly in the region just above and anterior to the globus major. It is usual to find small nodules of a hard fibrotic consistency on this part of the cord, from the size of a grain of rice to that of a hazelnut. Eosinophils will not be markedly increased in the blood picture unless microfiliariæ are present in the peripheral circulation.

Treatment. When the preoperative diagnosis has been made, treatment is surgical. It may be either conservative or radical.

Conservative treatment consists of the removal of all the lymphatics of the cord and the adjacent membranes and infiltrated tissues, as well as the anterior group of varicose veins, from the globus major to the inguinal ring, as in an ordinary varicocelectomy, in an effort to relieve symptoms and save the testis. In some advanced cases it may be necessary also to remove the inguinal glands by a separate incision in order to eradicate the entire chain of infested lymphatics and lymph-glands, which would otherwise constitute a perpetual source of the disease.

Radical treatment is carried out when the epididymis is involved in the filariasis of the cord. Here, in addition to the procedure mentioned above, epididymectomy followed by vasotesticular anastomosis is indicated, in order to save the physiological function of the testis. In the past, many authors recommended castration, but since the condition affects many younger individuals and is frequently bilateral, so drastic a procedure appears to be contraindicated unless there is evidence of advanced destruction of the testis due to some associated type of pathology. Inasmuch as the vas and testis are not involved in the filariasis of the cord, but maintain their integrity, the conservative procedure seems to be the method of choice. The radical operation has been described in the section on Operations upon the Vasa Deferentia (see page 746 (496)).

VARICOCELE

Definition. Varicocele is a common condition resulting from the presence of varicose veins within the spermatic cord, expressed in their dilatation and tortuosity and usually in their elongation, as well as that of the scrotum. It is about 25 times more frequent on the left side than on the right. Both sides are affected in about 7 per cent. of cases.

Classification. From an etiological point of view two types exist: (1) *symptomatic* and (2) *spontaneous* or *idiopathic.*

Symptomatic variocele, which is relatively rare, occurs as the result of pressure exerted by a renal neoplasm, which may occur in one of several ways: (1) invasion of the veins by the tumor itself; (2) thrombosis of the renal vein, and (3) production of a secondary enlargement of the regional lymph-nodes. Such varicoceles develop suddenly and painlessly in later life, at a period when various types of obstructive lesions are prone to appear. Physical examination will usually disclose the underlying cause. As a rule this may be found higher up in the abdomen, in the form of a renal neoplasm or a pyonephrosis, upon removal of which the varicocele will ultimately disappear. Anatomically these varicoceles have the same general characteristics as the spontaneous type, but they are usually larger than those of youth.

Spontaneous varicocele is a very common finding in early adult life, and may when small be regarded as almost physiological, causing no concern unless symptoms of pain and discomfort appear. In fact, it has been said that a minor degree of varicocele exists in at least 10 per cent. of all males submitted for military service. It may be bilateral or unilateral, but it is most commonly found on the left side of the scrotum.

Etiology. Among the commonest causes of spontaneous varicocele are the anatomical relations of the left cord, which not only is longer than the right, but is drained by a spermatic vein that empties into the renal vein at an abrupt right angle, without a valve; whereas the usually immune right spermatic vein makes an oblique approach to the vena cava, into which it empties through a valve that prevents reflux.

Other causes that have been suggested as playing a rôle in production of varicocele are persistence of fetal veins, presence of venous hypertrophy, habits of prolonged standing, straining of the abdominal muscles, chronic phlebitis or thrombosclerosis, defective valves in the spermatic veins, and, finally, traumatic lesions of the cord. It seems probable that the appearance of the condition during the early adult period is related to rapid developmental changes throughout the genital apparatus, which affect veins already predisposed to varicosity. In most cases, the condition retrogrades spontaneously in later life.

Signs and symptoms. As a rule, the testis is normal in shape and consistency but may at times be definitely smaller than normal. Varicosities may or may not be present on the surface of the scrotum, which is more or less relaxed. The veins within the scrotum are engorged and become tortuous; when the patient stands, they present a resemblance to a "bag of worms" so striking that the comparison is traditionally made. They respond to coughing with further swelling, but in the recumbent position or upon elevation of the scrotum, they slowly empty, and are thus differentiated from hernia, where the emptying of the scrotum is abrupt.

In robust persons varicocele causes no pain, but in anemic and weak individuals there is a sense of aching and dragging weight in all the mass of the scrotum. Testicular or referred pains may pass along the cord, and may produce an aching sensation in back, legs, abdomen or perineum, especially in youths who suffer with neurasthenia. Occasionally there are severe spasmodic pains of a colicky type. Discomfort is frequently increased toward evening, when the day's exertions have brought more blood into the affected veins. Long walks, riding, and other exercise increase the severity of the picture at the end of the day.

Mental depression often accompanies varicocele in the very young, who do not realize the usual harmlessness of the condition, and fear that they are about to become impotent. If varicocele appears before puberty, a somewhat small and atrophic testis may result, but in the usual case varicocele does not affect the normal growth and development of the testis. A slight degree of varicosity is in fact to be considered as virtually normal. In very marked cases the testis may lack its normal elasticity and tenseness. It is not at all infrequent to find a concomitant hydrocele or spermatocele, but the conditions are not related, the hydrocele or spermatocele being only incidental.

Pathology. When a varicocele is dissected, all the veins, both those of the anterior group surrounding the pampiniform plexus and those of the posterior group passing behind the vas, are seen to be dilated, elongated and tortuous, with anastomoses of abnormal caliber. The anterior group is the earlier to be affected, but later on the posterior group, and even the veins of the parenchyma of the testis, may be found participating in the process. Histologically, the lesions differ in no way from those observed in varicose conditions of the limbs.

Diagnosis presents very little difficulty. Palpation through the scrotum gives the wormlike sensation to the examining fingers already referred to. The thrill on coughing is also characteristic, differentiating varicocele from hernia with the expansile impulse of the latter. Reduction of size when the patient lies down also points to a diagnosis of varicocele, together with an increase in size when a finger is placed lightly over the external inguinal ring, obstructing the flow of blood from the pampiniform plexus.

Treatment. The treatment of varicocele is (1) conservative or (2) radical.

Conservative treatment. In cases in which the condition gives no symptoms, a suspensory should be advised and suitable hygienic measures recommended. As a rule, operation in younger individuals is neither necessary nor advisable.

Radical treatment. In the surgical treatment of varicocele many types of operation have been tried, including both closed and open procedures. Among the closed methods used in older times may be mentioned the subcutaneous ligature of the varicose veins. In more recent times the injection method, which consists of introducing some sclerosing substance into the large varicose veins of the pampiniform plexus, has been used, but these two closed methods, although easy of execution, are not without complications and are not to be recommended for indiscriminate use in the average type of case.

The open operative procedures are safer, and for these various technics have been suggested from time to time by different authors. These include abdominal procedures for the extraperitoneal ligation of the spermatic vein at a point high up in the abdominal cavity, without touching the pampiniform plexus of veins in the scrotum, as described by Ivanissevich, Arce, and others. Londres' method consists of suspension of the testis by a flap of fascia and resection of a few veins of the plexus. The two operations most in use today are the high and the low operation to expose the cord. The former is performed through a high incision in the inguinal region of the abdomen as in hernioplasty, while in the latter the incision to expose the varicose veins of the cord is made in the scrotum below the external inguinal ring.

The classic treatment, however, and the one I prefer, is the excision of the anterior group of varicose veins from this tortuous plexus, without injury to the spermatic artery or interference with the blood supply of the testis. The upper stump of the cut group of veins, properly ligated, is either transfixed and anchored to the muscles at the internal inguinal ring, or it may be left alone to be retracted into the abdominal cavity; the lower end is anchored to the external oblique muscle or to the floor of the external inguinal ring, thus suspending the testis.

Technic of operation. The technic of choice in large painful varicocele consists of opening the scrotum by a simple incision 3 to 5 cm. in length, high up at the scroto-inguinal junction, exposing the elements of the cord by blunt dissection, and separating the vas deferens and spermatic artery from the anterior group of veins, in order to save the blood supply of the testis. Both ends of the bundle of thick veins are then clamped and cut, and a length

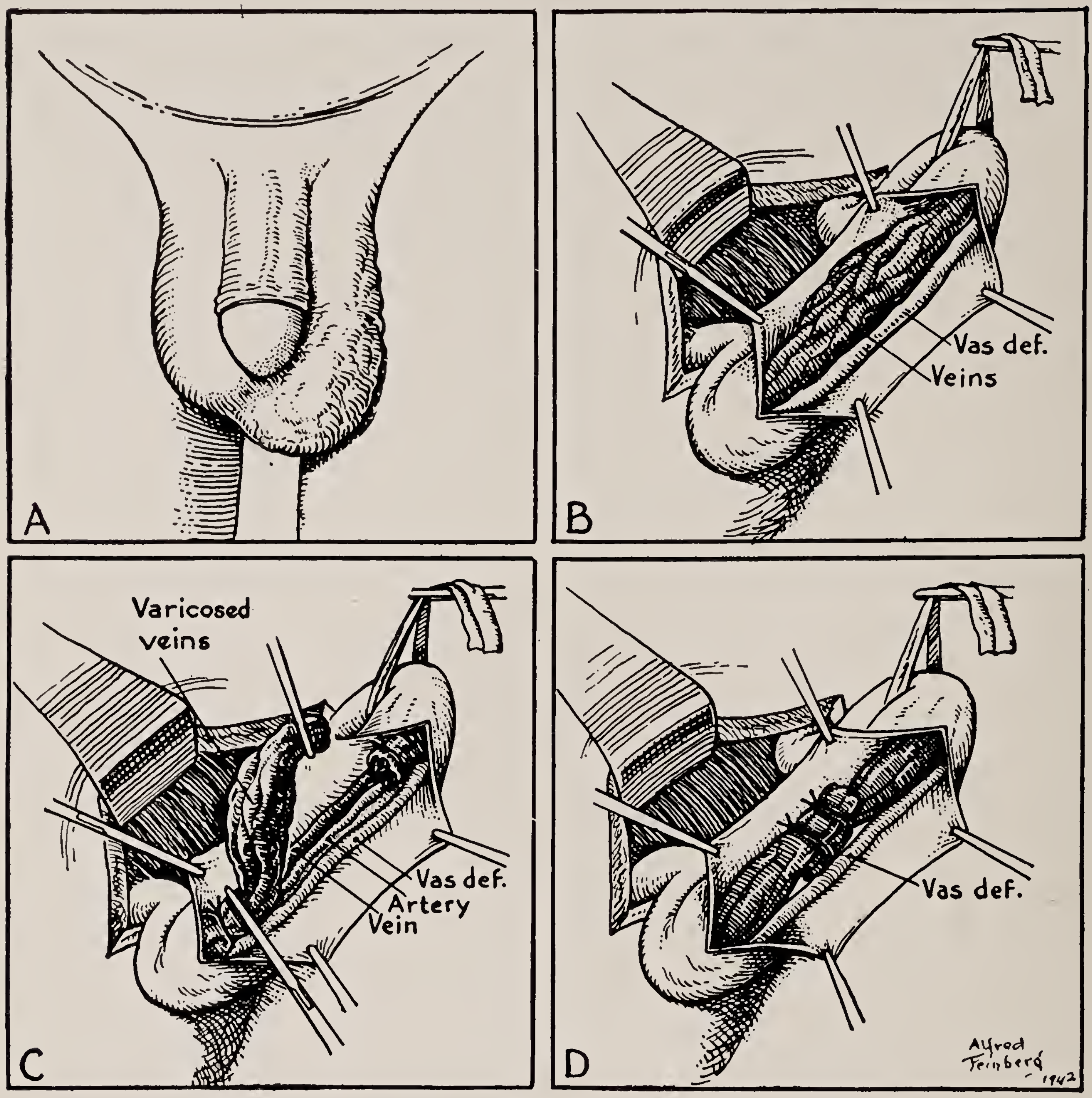


FIG. 59. Operative technic for cure of varicocele.

A. Drawing to illustrate the incision high up in the left side of the scrotum.
B. The cord is exposed and brought out of the wound; its investing tunic is laid open, revealing the greatly distended varicose veins of the pampiniform plexus, and also the vas deferens.
C. The veins of the anterior group are doubly clamped, ligated and sectioned at both ends, with care not to injure the vas deferens or compromise the blood supply of either the testis or the vas.
D. After removal of the sectioned bundle of varicose veins, the two stumps are dissected, brought together with an overlap and held by two silk ligatures, thus serving to elevate and support the testis. The wound is closed without drainage in the usual manner.

of about 4 or 5 cm. is removed, from the globus major to the external inguinal ring. The cut ends are ligated with silk by transfixed sutures, and the two stumps brought together and tied, thus shortening the cord and fixing the testis in such a way as to elevate it into its proper position (Fig. 59, A, B, C, D). The wound is closed in the usual manner with or without drainage, after which a suspensory is applied to immobilize the scrotum. This operation can be carried out under any form of anesthesia, but it is best to use general narcosis, particularly with neurotic patients. Rest in bed is advisable for a week or 10 days and the patient should continue to wear a suspensory for several months after operation.

When varicocele is associated with other types of pathological lesions in the scrotum, such as inguinal hernia, hydrocele, spermatocele, and long pendulous scrotum which may require resection, it may be desirable to correct all of these conditions at the same time. The author has recently seen a patient upon whom he operated for a complicated condition of this kind 18 years ago, with results that have stood the test of time. This patient, who was 38 years of age at the time of operation, was at that time suffering with a hydrocele of the cord, a hydrocele of the tunica vaginalis testis, a long pendulous scrotum, and an exaggerated varicocele, all of which were resected at one sitting, followed by complete cure.

Complications. Among the most common complications of varicocele observed after unsuccessful operation are infection of the wound for lack of proper drainage, hemorrhage into the scrotum following faulty ligation of vessels, bleeding within the abdomen from loosening of the ligature on the upper stump, atrophy of testis due to cutting off of its blood supply, formation of secondary hydrocele, hematocele, and pyocele, and appearance of orchido-epididymitis for lack of proper support and immobilization of the scrotum after the operation.

Results. When the operation for varicocele is properly executed in well selected cases, the results are as a rule entirely satisfactory. Most of the patients are free from painful symptoms, they gain in comfort and are able to lead a normal sexual life. Clinical experience and reports of many authors in the literature support these assertions.

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SECTION VI

OPERATIONS UPON THE GENITO-URINARY ORGANS

PART V

OPERATIONS UPON THE URETHRA

BY

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CHAPTER XVII

URETHROSCOPY: OPERATIONS UPON THE URETHRAL MUCOUS MEMBRANE: REMOVAL OF URETHRAL CALCULI

URETHROSCOPY

In the instruments at present in use, electric light is the invariable luminant, and it is used in one of two methods—either directly, the lamp being placed at the inner end of the urethral tube, or reflected from a lantern fixed to the outer end of the tube. The former variety gives a very bright illumination, but is open to the objections that the lamp tends to become overheated during a prolonged examination, and may scorch the urethral mucous membrane, that application of fluids to the mucous membrane can only be made after withdrawing the lamp, and that the lamps are very small and sensitive, and are quickly destroyed by variations in the electric current and require frequent renewal.

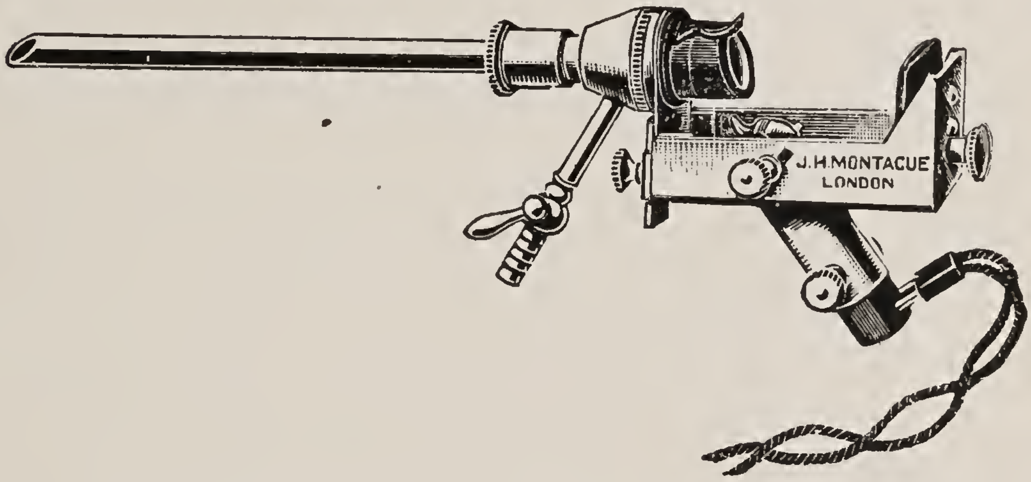

Fig. 400. Wyndham Powell's Urethroscope.

The various modifications of the Leiter principle of a fixed lantern from which light is reflected along the urethral tube are more serviceable, and if well made and carefully regulated give an equally good illumination.

To this form of urethroscope the air-distension apparatus originally introduced by von Antal is fitted. The modification by Dr. W. Wyndham Powell is a useful instrument (see Fig. 400).

There is a square lantern-box in which a powerful electric lamp is set obliquely. Immediately above the light is a movable lens which concentrates the rays upon a small reflecting mirror at the upper end of the box. This mirror directs the light into the nozzle which fits into the upper end of the urethral tube. The nozzle is closed at its upper end by a glass window which springs open on releasing a small catch. A tube provided with a stop-cock enters the nozzle laterally, and is connected with a rubber bulb which supplies the air-pressure. The rubber bulb should be the size of a melon, in order to give air-distension during a prolonged examination. A segment is cut from the circumference of the reflecting mirror, so that the operator's gaze, directed over the edge which corresponds to the cord of the segment, falls closely parallel with the rays of light which project into the urethral tube. Another handy form of urethroscope is made by Schall (see Fig. 401).

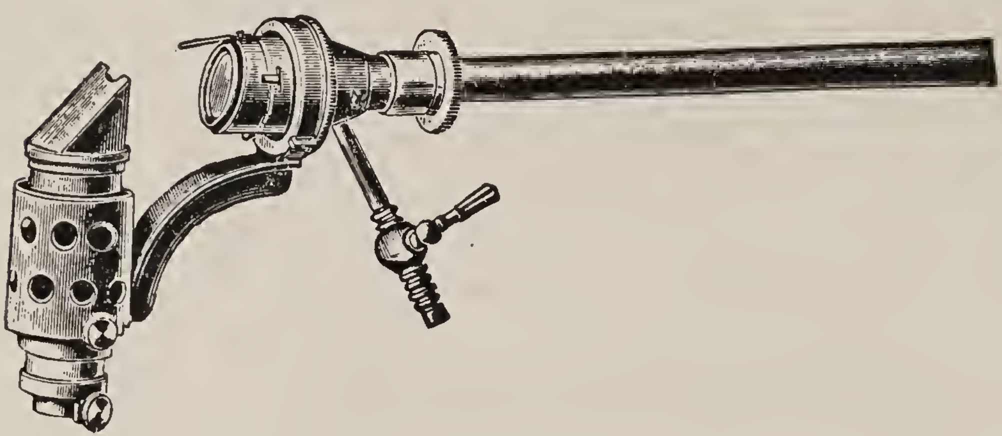
Fig. 401. Schall's Urethroscope.

The urethral specula are five inches in length, and of different calibre (see Fig. 402). Nos. 23 to 26 Charrière are useful sizes. The distal end of the tube may be cut obliquely or transversely, the former giving a slightly larger field. An obturator fills the lumen of the tube during the insertion into the urethra, and is removed when the required depth is reached. The distal end of the tube must be smoothly rounded, that it may not lacerate the delicate mucous membrane of the urethra. The obturator must fit accurately, and there should be no abrupt shoulder at its junction with the tube.

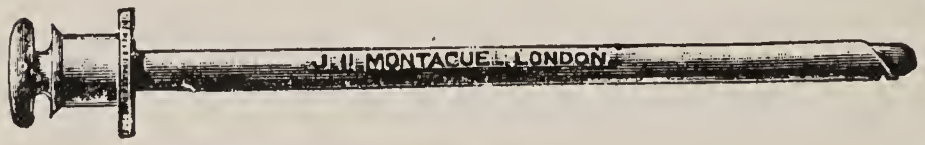

Fig. 402. Urethral Speculum.

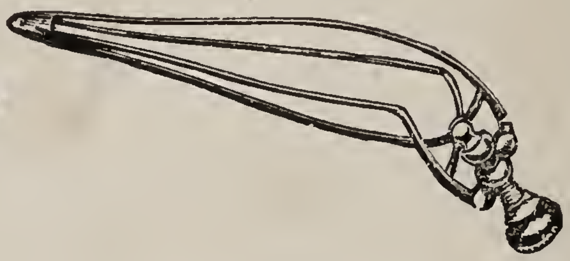
Fig. 403. Smith's Urethral Speculum.

An inverted cup may be provided at the prominent end of the tube, and receives the glans penis. It is supposed to prevent the escape of air when the urethra is inflated, but it is unnecessary. The tubes may, for convenience of noting the position of diseased portions of the urethra, be marked in half-inches. It is convenient to have one or two short tubes (2 to 2¼ inches long) for examination of the outer portion of the penile urethra. A wire speculum (Smith's) (see Fig. 403) or the slightly more elaborate speculum of Watson may be used with reflected light for examination of the first inch or so of the urethra. For examination of the prostatic urethra a longer tube (6¾ inches) with a beak (1 inch) set at an angle to the shaft should be used (see Fig. 404). An open window is situated at the convexity of the junction of beak and shaft. The lumen is filled by an obturator during introduction. When the tube is in position it displays the verumontanum and surrounding parts of the floor of the prostatic urethra.

The urethroscope is used in the following manner: The canula and metal obturator are boiled before use. The instrument is lubricated with sterile olive oil. The patient is recumbent on a high couch with the surgeon standing on his right side, or he may occupy an examination chair with the legs well flexed, and the surgeon sits between the widely separated knees. The penis is grasped with the left hand so that the second and third fingers lie behind the corona glandis, leaving the first finger and thumb free to manipulate the meatus and to support the tube and urethroscope after it is introduced. The penis is held erect and the tube gently introduced. During the introduction any points of special tenderness are noted, and if the instrument hitches it should not be forced onwards, but the examination commenced from this spot. Not infrequently the passage of the instrument is interrupted at the peno-scrotal angle, but by bringing the tube nearer the long axis of the body it glides onwards.

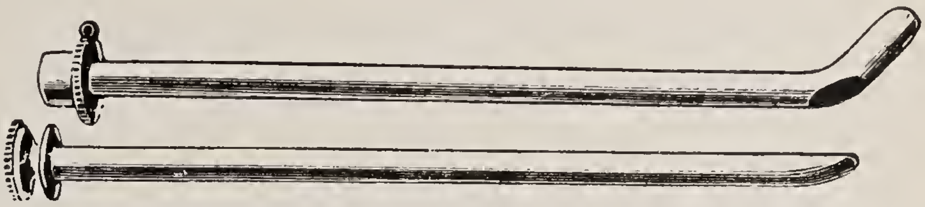

Fig. 404. Speculum for the Prostatic Urethra. The obturator is shown below the tube.

It should pass on without actual obstruction to the hilt. The thumb and forefinger of the left hand grasp the flange of the canula, the obturator is withdrawn, and a urethral sponge on a holder gently run down the tube to mop up the lubricating fluid. This is withdrawn and the urethroscope fitted on to the tube. The rubber balloon has previously been inflated and the stop-cock and glass window closed.

The light is switched on and the urethral mucous membrane examined. The weight of the instrument should be supported by the thumb and first finger of the left hand, which grasp the proximal end of the canula, and the hand is steadied by the fourth finger resting on the pubes.

The mucous membrane of the urethra is pale pink, varying in depth of colour from that of the conjunctiva to that of the inner surface of the lip. It shows fine longitudinal striation due to the direction of the blood-vessels. The bulbous urethra is closed at its inner end by the membranous urethra tightly grasped by the compressor urethræ;

examined with the urethroscope, there is a central dimple with radiating folds (from 2–8 in number, usually 5 or 6), each fold showing a longitudinal striation. If a little air is admitted by turning the stop-cock the opening will recede, and it will be seen that the aperture lies on the roof of the bulbous urethra, the floor rising up to meet it. A little more air-pressure will raise the upper or anterior margin of the opening into a sharp ledge which is in the form of an arch, and an over-pressure of air will result in the orifice gaping and then contracting as the deep urethra swallows a gulp of air. Gradually withdrawing the tube, the roof and floor should be carefully examined. A median white ridge may sometimes be seen on the floor of the first inch or so of the bulbous urethra. This indicates the line of the ducts of Cowper's glands, but it is seldom that the openings of these ducts can be seen. Very rarely inflation of the urethra will open up the orifice of one of these ducts, so that it resembles a pocket or diverticulum.

Withdrawing the tube still further, the openings of the lacunæ on the roof begin to appear. These are seen with or without the aid of inflation. They show fine red points about the size of a pin's head or less. They are frequently round or oval, but may also appear in the healthy state as fine slits. They become more numerous towards the anterior part of the roof of the canal. At the peno-scrotal junction a thick transverse fold appears on the floor which is due to the duplication of the urethra at this point, where it is slung up by the suspensory ligament of the penis. This should not be mistaken for a stricture. It disappears on bringing the penile urethra into the axis of the bulbous urethra and stretching the penis. The urethral wall falls over the end of the urethroscope tube, and a slight dimple is seen in the middle, from which folds radiate outwards. Under air-distension the urethra is converted into a long tunnel, and the tube must be turned up or down or laterally to inspect the walls. High air-pressure leads to a stretching out of the roof of the urethra into shallow depressions with intermediate ridges which form arches when viewed from the front. These fibrous rings are sometimes mistaken for strictures.

At the junction of the fossa navicularis and the penile urethra two lateral folds are frequently seen, and on the roof at this point the opening of the lacuna magna, with a well-marked transverse fold below it, is usually noted.

Examination of the prostatic urethra with the prostatoscope should be reserved for cases where other methods of diagnosis have failed. Ten or fifteen minims of a 2% solution of cocaine are dropped into the anterior urethra by means of a rubber-topped pipette, and the fluid is massaged back into the prostatic portion. Or the cocaine may be instilled by means of a Guyon's syringe into the deep urethra and a drop or two expressed from the syringe as it is withdrawn through the membranous portion.

The patient is recumbent on a high couch with the surgeon standing on his right side. The elbowed canula is boiled, and, with the obturator in position, is well oiled and introduced into the urethra. When the beak engages in the membranous urethra the instrument is fully depressed and pushed on into the prostatic portion. Either at this time or before the introduction of the prostatoscope, the pelvis of the patient is raised on a sand-pillow. The obturator is now withdrawn, and the excessive moisture removed by a swab. The lantern is attached, and the light switched on. No air-distension is used in the prostatic urethra, so that the bellows are dispensed with, and the urethroscope window is open. The verumontanum lies in the field, and the opening of the sinus pocularis can be recognized as a dimple at its summit. At the sides of the verumontanum the prostatic sinuses are seen. A puffy swelling and redness of the lips of the sinus pocularis denotes inflammation in that pocket. Small polypi may be observed in the neighbourhood of the verumontanum in some old-standing cases of gleet.

Before withdrawing the prostatoscope the obturator should be replaced, lest the edge of the window lacerate the inframontanal ridge in its outward passage.

OPERATIONS UPON THE URETHRAL MUCOUS MEMBRANE

Open inflamed lacunæ are a source of continual or recurrent gleet. A single lacuna or many may be inflamed. The outlet of the lacuna is sometimes obstructed so that the discharge is retained.

Cauterization of inflamed lacunæ. An efficient method is to tip a fine stiff wire with nitrate of silver by heating it to a white heat and then drawing it across a stick of solid nitrate of silver, and allowing the melted nitrate to run to the end of the wire and solidify there in a fine bead. A large urethroscope tube is passed down to the offending lacuna, and the mucous membrane dried with a pledget of cotton-wool on a holder. A brilliant light is necessary, and the end of the canula is steadied over the required spot. The light of the urethroscope is switched on, and the glass window opened. The fine wire is now passed along the tube down to the orifice of the lacuna, into which it is passed and then withdrawn. A pledget of cotton-wool soaked in salt solution may now be applied to limit the action of the silver nitrate. Several sittings may be required where a number of lacunæ are affected.

Other methods may also be employed. The inflamed lacuna may be touched with a very fine electro-cautery, or electrolysis may be used. A fine platinum wire is introduced into the orifice of the lacuna and connected with the negative pole of a battery. The positive pad terminal is placed upon the thigh. The current is switched on, and in a few seconds the whitening of the mucous membrane shows that electrolysis is complete.

Incision of inflamed lacunæ. Another method is to pass a very fine probe-pointed knife (Weber's knife, see Fig. 405) into the lacuna and slit it up. A cotton-wool swab damp with nitrate of silver solution (20 grains to the ounce) is then applied, and easily controls any oozing which might conceal other lacunæ which are to be treated in the same way.

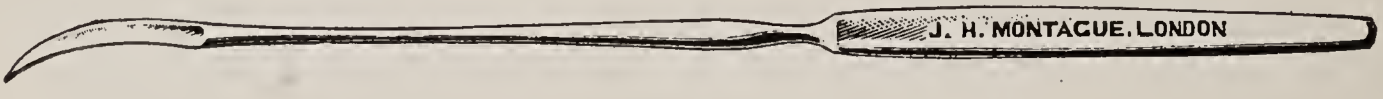

FIG. 405. WEBER'S URETHRAL KNIFE.

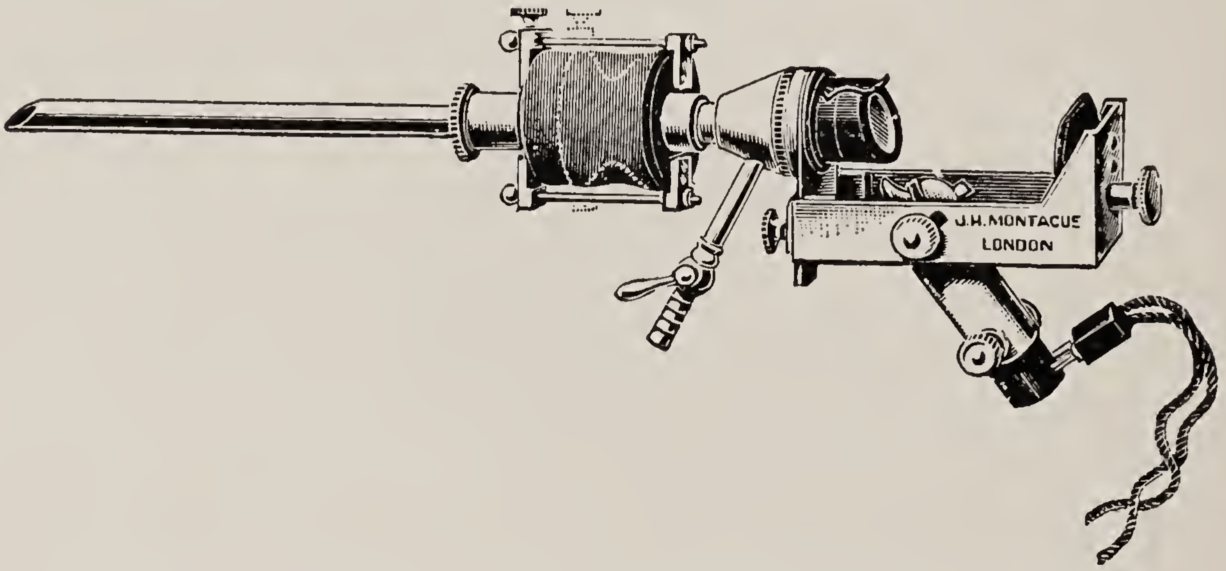

FIG. 406. WYNDHAM POWELL'S OPERATION URETHROSCOPE.

In carrying out these delicate manipulations it is difficult to fix the lax urethral mucous membrane and to expose thoroughly the opening of the lacunæ, since the urethra must be deflated by opening the window in order to introduce the probe or knife. This difficulty has been overcome by the introduction of an ingenious instrument by Mr. Wyndham Powell, by means of which it is possible to operate in the air-distended urethra under the guidance of the eye. Mr. Powell has given me the following description of his apparatus (see Fig. 406): It consists of a tube of thin rubber 1½ inches in length and diameter, and secured at each end by a metal disk, one disk having in its centre a mount to plug into the urethral canula, and the other a mount to receive the nozzle of the urethroscope. This concertina-like apparatus, which is interposed between the urethroscope and the canula, allows all the necessary movements for intra-urethral instrumentation, while preventing the escape of air. The movements in the longitudinal direction are quite free, except that on collapsing the instrument to project the intra-urethral probe the internal air-pressure has to be overcome. The other movements are restricted by two side pins which keep the urethroscope more or less in alinement with the canula, from which it is separated by the pneumatic mount. Inside the nozzle of the urethroscope is fixed a fine screw, and into this is screwed the instrument (probe, knife, &c.) selected for use. The urethroscope thus forms the handle of the intra-urethral knife, probe, or curette.

The intra-urethral instrument, when screwed into position just before use, must not project beyond the distal end of the canula, or the urethra may be injured before inflation.

Removal of warts and polypi. Papillomata are met with in the anterior urethra in some cases of persistent gleet. There may be a few small warts, or the whole length of the penile urethra may be carpeted with them. They are easily detached from the mucous membrane, and may be removed by seizing them with alligator forceps. The urethroscope tube is passed along the urethra to the deepest of the warts, which is grasped with the forceps and pulled off the mucous membrane with a sharp tug. The tube should be placed so that the wart lies against the edge of the orifice, and the forceps are guided along the side. Oozing of blood quickly obscures the view, and is controlled by the pressure of a pledget of cotton-wool damp with silver nitrate solution (10 grains to the ounce) or suprarenal extract. The tube is gradually withdrawn, removing other warts in the same manner. Usually several sittings are necessary.

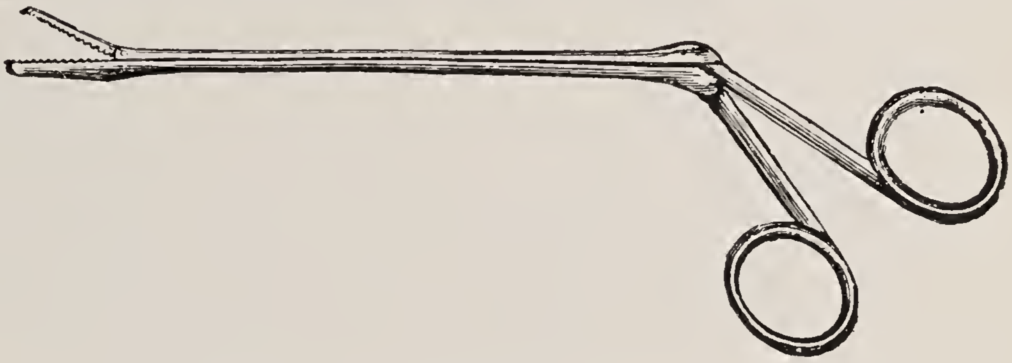

FIG. 407. ALLIGATOR URETHRAL FORCEPS.

The warts are sometimes so lightly attached to the mucous membrane that they are shorn from its surface by the passage of a large tube. I had a segment taken out of one part of the circumference of a urethroscopic tube and the edge of the recess sharpened. A single wart may be manœuvred into this recess and mown down by a sudden push of the tube. Ebermann uses a urethroscope tube, the end of which is closed. An oval eye is provided at one side. The wart is manœuvred into this eye, and then a second tube with an open sharp end is passed along inside the first and the wart cut off.

Small pedunculated polypi in the neighbourhood of the verumontanum are removed by alligator forceps (see Fig. 407) passed along a prostatoscope tube and a pledget of wool soaked in silver nitrate solution applied to the base.

REMOVAL OF CALCULI FROM THE URETHRA

FROM THE ANTERIOR URETHRA

The calculus almost invariably lies behind a stricture and a perineal fistula is frequently present also. There may be one or several calculi and they may extend into the prostatic urethra.

Operation. The perineum is prepared and a staff passed into the urethra. Where a large calculus is present the staff will not pass into the bladder, and if a narrow stricture be present the attempt need not be made.

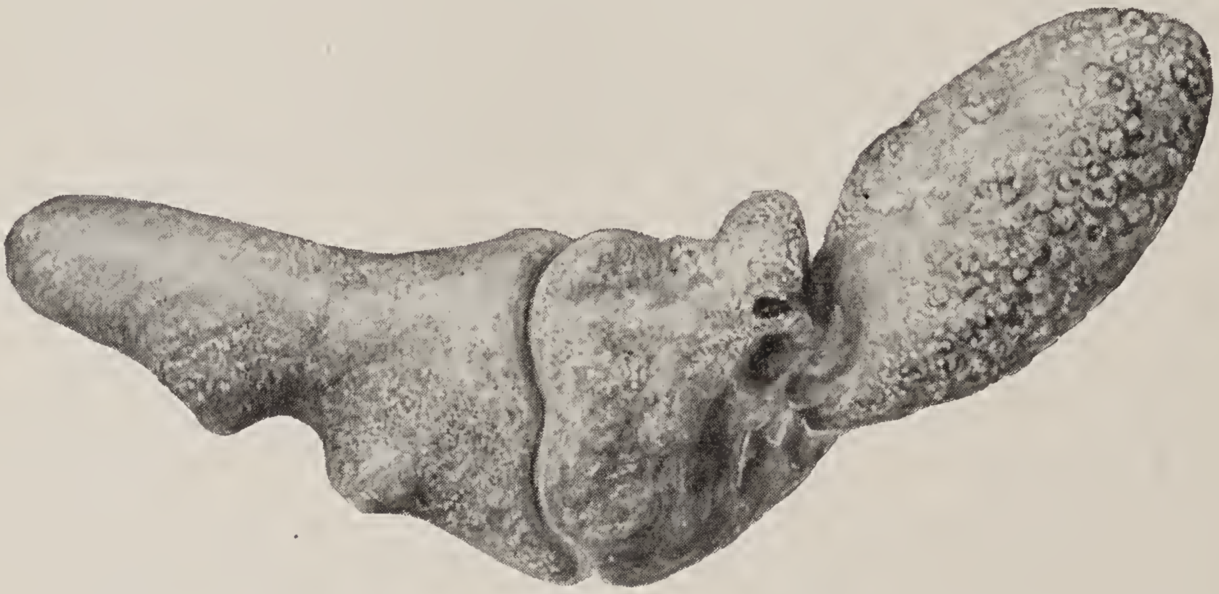

Fig. 408. Calculi forming a Complete Cast of the Ureter from the Vesical Opening to the Penile Urethra. On the right is a cast of the dilated prostatic urethra separated by a constriction corresponding to the membranous urethra from the dilated bulbous urethra. There was a large perineal fistula at the under surface of the facet between the two calculi. (*Author's case.*)

The patient is placed in the lithotomy position and an incision is made in the middle line over the calculus, which can be felt from the surface. If a fistula be present, this is dissected down to the urethra in the manner described on p. 795 and the urethra opened. Where the fistula is large and direct, the urethra is opened up from this point forwards. The calculus is now grasped in small lithotomy forceps and can be removed without difficulty if it be loose and of moderate size. Sometimes, however, it is adherent to the urethral wall and the mucous membrane must be peeled off it. Where several calculi of large size are present the extraction of one will facilitate the removal of the rest. If the calculus projects into the prostatic urethra, a constriction will be found at the membranous urethra and adds to the difficulty of removing the calculus (see Fig. 408). A curved sharp-pointed bistoury should be passed along the calculus and the membranous urethra incised at the point of constriction. The gloved forefinger of the left hand is then introduced into the rectum and helps to push out the prostatic portion of the calculus.

The calculi having been removed, a probe director is passed from behind forwards through the stricture behind which they lay and the stricture freely cut upon this. A large steel sound is now passed from the external meatus to ascertain if any narrow part still remains uncut. If it be arrested in front of the external opening in the urethra a urethrotome guide is passed and the constriction severed.

The question of immediate repair of the perineum must now be considered. If the urine be foul and cystitis present, it will be better to tie a large rubber tube in the perineal wound and by this means drain the bladder for some days. After this a catheter should be tied in the urethra and the perineal wound encouraged to heal. If a defect or fistula remains, one of the operations described under the section dealing with these must be performed at a later date.

If the tissues be healthy and the urine not foul, the wound should be closed at the time of the operation by a plastic operation.

FROM THE PROSTATIC URETHRA

Operation. A grooved staff is passed into the urethra, and if it does not pass the calculus in the prostatic portion it will enter far enough to act as a guide for the first part of the operation. The patient is placed in the lithotomy position and the membranous urethra freely opened by a median perineal incision. The right forefinger is introduced alongside the calculus, which is then loosened from its surroundings. This is often a matter of some difficulty, but eventually the finger can be swept round the calculus and a pair of lithotomy forceps fitted upon it and the mass extracted by gradually peeling the soft tissues off it (see Fig. 409).

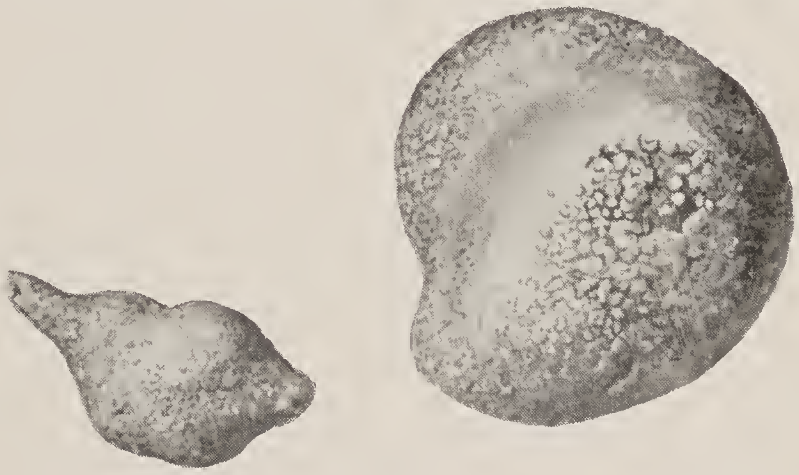

Fig. 409. Urethral Calculi. Large calculus removed from prostatic urethra and smaller calculus from the bulbous urethra. (*Author's case.*)

After the removal of the stone the large dilated prostatic urethra should be flushed with a copious stream of biniodide of mercury (1 in 15,000) to remove any small fragments. The right forefinger is now pushed through the vesical sphincter and the bladder explored with this and with a sound for calculi. Sometimes the calculus lies in a pocket communicating with the prostatic urethra by a small opening through which it projects. The opening must be dilated with the finger and the calculus shelled out. Care should be taken to open the pocket freely into the prostatic urethra after the calculus has been removed.

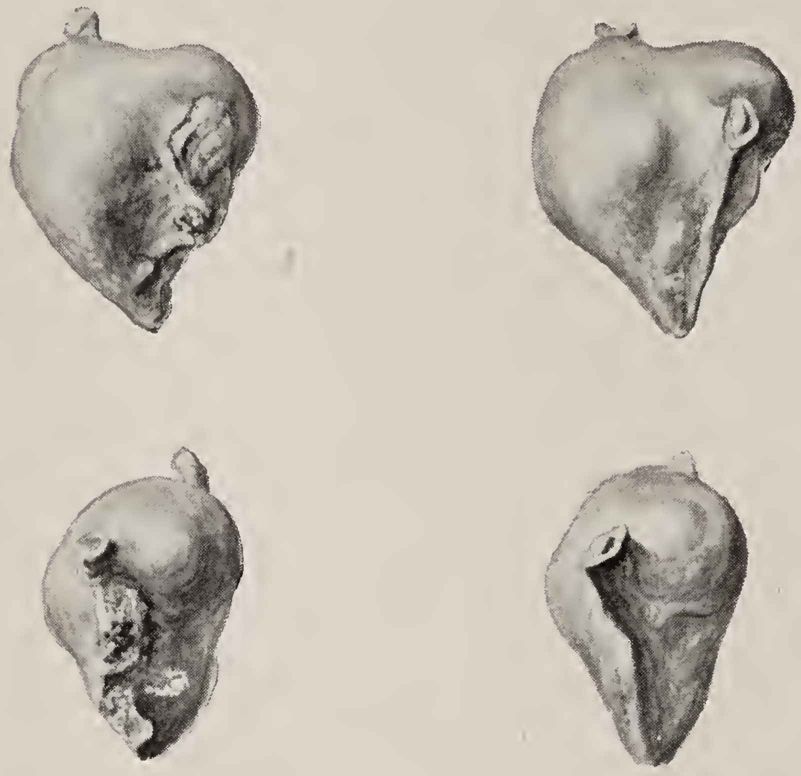

Fig. 410. Recurrent Urethral Calculi. Front (above) and side (below) view of two exactly similar calculi removed from a prostato-urethral pouch at an interval of twenty months. (*Author's case.*)

Results. Urethral calculi frequently recur if the precautions given above are not attended to, and sometimes in spite of them. A patient aged twenty-nine years, on whom the writer operated for prostato-urethral calculus and vesical calculus, had undergone sixteen previous operations for stone in the prostate and bladder. The writer removed a prostato-urethral calculus, the exact counterpart of one which he had removed from the patient twenty months before (see Fig. 410).

CHAPTER XVIII

OPERATIONS FOR INJURIES TO THE URETHRA

EXTERNAL URETHROTOMY AND SUTURE OF THE URETHRA IN WOUNDS OF THE PENILE URETHRA

Operation. A bougie is introduced along the urethra and the penis is steadied by an assistant. The skin wound should be extended longitudinally, the sheath of the corpus spongiosum exposed and incised, and the wall of the urethra defined in front and behind the wound. The edges of the urethral wound are trimmed and brought together by fine catgut sutures, so that the closed wound is transverse. The stitches do not pierce the mucous membrane. The sheath of the corpus spongiosum is brought together by a second row of catgut sutures and the skin united by interrupted silkworm-gut sutures, forming a longitudinal wound.

After-treatment. A catheter is retained in the bladder for forty-eight hours and then removed, and a soft rubber catheter passed very carefully three times daily for four or five days, after which time the patient is allowed to pass urine himself. After the operation the rectum is emptied by enema and a suppository containing lupulin (gr. iv), camphor monobromide (gr. iv), and extract of belladonna (gr. ¼), introduced each night to prevent the occurrence of erections, which are sometimes troublesome.

When the urethra is completely severed and the corpora cavernosa remain intact, immediate suture should be carried out on similar lines.

EXTERNAL URETHROTOMY IN RUPTURE OF THE BULBOUS OR MEMBRANOUS URETHRA

Operation. A metal catheter (No. 10) is well oiled and passed gently along the urethra, keeping to the roof of the canal. If the catheter passes the point of rupture and enters the bladder, the urine is drawn off and the instrument kept in position and the patient is prepared for operation. If the catheter does not pass into the bladder, it should be left in the urethra, so that the penile end of the urethra can be identified.

The patient is placed in the lithotomy position. The perineum is shaved and cleansed. An incision is made into the hæmatoma. If, on attempting to pass the catheter, the rupture be found to lie deeply in the position of the membranous urethra, a curved, transverse, prerectal incision with the convexity forward will give the best exposure; but where the rupture lies in the bulbous urethra, and this is the usual position, a median incision is preferable. The fascia of Colles is incised and picked up in forceps on each side and held apart. As this layer is incised, a jet of dark blood which has been pent up usually escapes. The perineal muscles are bruised and infiltrated with blood, and a good head-light is necessary for the further steps of the operation. Any bleeding point is secured and a search for the ends of the urethra commenced. The clots of blood and shreds of lacerated tissue are removed. A stream of hot lotion from an irrigator is useful for this purpose and serves also to control oozing.

If the urethra has not been completely severed, a band of mucous membrane will remain in the position of the roof of the canal. A catheter passed through the penile urethra may be guided along this shred into the membranous urethra and thence into the bladder. There will then be no difficulty in finding the torn edges of the urethra. These are picked up in fine forceps, and the frayed margins are trimmed and united as accurately as possible with catgut sutures.

The metal catheter is replaced by a rubber or gum-elastic instrument, which is secured in position.

If the urethra has been completely severed, the penile end of the canal will be found upon the instrument which was passed from the external meatus. A silk suture is passed through the wall of the canal for future identification and search is now commenced for the vesical end of the urethra. This may be found as a loose shred of tissue, or it may resemble the twisted end of a large blood-vessel. Sometimes the urethra is found by the persistent bleeding of a small vessel in its wall. Every depression should be carefully probed under a strong light. Should a careful search fail to reveal the stump of the urethra the gloved forefinger of the left hand may be introduced into the rectum, and when placed at the apex of the prostate will indicate the exact position of the membranous urethra; by probing at this spot the opening may be found. Lastly, pressure above the pubes by an assistant will cause some urine to trickle from the over-distended bladder and betray the position of the vesical stump of the urethra.

If the search be successful, the urethra is picked up in fine forceps and approximated to the penile stump. A gum-elastic catheter is passed along the penile urethra and projects into the wound. It is now manipulated into the vesical stump of the urethra and pushed on into the bladder, without, however, allowing more than a few drops of urine to escape. The torn ends of the urethra are now drawn together and united with catgut sutures.

The cavity is lightly packed with strips of iodoform gauze and a drainage tube introduced down to the urethra. The perineal muscles and the skin are brought together, leaving ample room for the tube and gauze. The gum-elastic catheter in the urethra is fixed in position by tying a piece of silk or narrow tape around it and bringing the ends along the sides of the penis, and fixing them there by a strip of adhesive plaster longitudinally placed on each side.

Suprapubic drainage of the bladder should now be established. If the bladder be not already distended with urine, 12 or 14 ounces of warm boric lotion are introduced through the catheter by means of a syringe. The steps of the operation will be found on p. 631.

A ½-inch diameter rubber drainage tube is introduced into the suprapubic opening and the urine is drained away by an apparatus. The suprapubic drainage is continued for a fortnight. The catheter is retained for four days and then removed, and the perineal drain is replaced by a strip of gauze at the same time.

Should the search for the vesical end of the urethra prove fruitless, a suprapubic cystotomy should be performed and a bougie inserted into the vesical end of the prostatic urethra and made to project in the perineal wound. The vesical stump of the urethra is easily found and a catheter guided from the penile portion into this and passed into the bladder. The operation is now completed as before.

Should the urethral wall be so extensively destroyed that the ends of the tube cannot be approximated, they should be stitched to the soft tissues or skin of the perineum, so that at a later date, when a plastic operation is performed to close the fistula, the ends of the urethra may be easily identified.

After the healing of an injury to the urethra, whether slight or severe, instruments should be passed in order to make certain that contraction of the urethral scar has not taken place, and if a narrowing of the canal is found the regular passage of instruments should be arranged or excision of the stricture may be performed. If there be no sign of stricture the patient should return for examination at intervals.

Some discussion of the following points is necessary:—

1. *The perineal incision and search for the urethra.* When the rupture of the urethra is far back, and especially if it be in the membranous urethra, a transverse prerectal incision will give a better exposure. It has been advocated by Bazy, Legueu, Riche, and Roux.[1]

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[1] *Annales des maladies des organes génito-urinaires,* 1904, vol. xxii, p. 187.

2. *Suture of the urethra.* Suture of the urethra frequently fails to bring about immediate union of the torn ends of the urethra and some surgeons are opposed to the use of sutures. Rutherfurd,[1] with considerable experience in the treatment of ruptured urethra, opposed the use of sutures on the ground that they were an 'unnecessary complication of the healing.'

The use of silk or other suture material, which is not readily absorbed and may act as an irritant, is no doubt objectionable, but fine catgut does not possess these disadvantages, and the use of some means of approximation of the torn ends of the urethra has such obvious advantages that the writer strongly recommends it.

3. *The bladder drainage.* Some authorities advise suprapubic puncture of the bladder for the initial retention of urine, followed by repeated aspiration of the bladder several times in the twenty-four hours for several days to prevent the urine passing along the urethra and soiling the wound. Neither this procedure nor the voluntary efforts of the patient to retain the urine can, however, be relied upon. The passage of some urine along the urethra is almost certain to take place and extravasation of urine or perineal abscess is the result.

The method of suprapubic drainage and immediate suture of the urethra was recommended by Gilbert Barling[2] in 1891. Rutherfurd[3] independently developed a somewhat similar procedure in 1898. He tied a soft rubber catheter in the urethra and drained the bladder by suprapubic cystotomy. The urethra was left unsutured.

Mortality. (*a*) Uncomplicated rupture of the urethra.

Kaufmann[4] collected from the literature 205 cases of injury to the urethra, 29 of which died, a mortality of 14.15%. The complication of urinary infiltration seriously affected the mortality figures and produced a death-rate of almost 36% in the cases in which it occurred. Treatment by retained catheter produced a mortality of 18.17%. When it is remembered that the latter were the cases in which the damage was least extensive this mortality is very high.

In 91 cases where perineal section was made within the first two days after the injury 8 died, a mortality of 8.79%. Of 24 cases in which perineal section was made after several days (eight to ten days) 8 died, a mortality of 20%.

(*b*) Rupture of the urethra with fracture of the pelvis.

Of 48 cases in the Kaufmann collection 20 died (40%). Oberst[5]

[1] *Lancet,* September 10, 1904.

[2] *Birmingham Medical Review,* 1891, vol. ii, p. 321.

[3] *Glasgow Hospital Reports,* 1898, vol. i.

[4] *Loc. cit.*

[5] *Volkmann's Sammlung. Klinische Vorträge,* No. 210.

found that in 16 cases submitted to perineal incision 4 died (25%), in 12 cases where a catheter was retained 5 died (42%), and in 8 cases where suprapubic puncture was practised 3 died (37%).

Martens[1] collected 17 cases of ruptured urethra, in 4 of which there was also fractured pelvis. One patient died, a mortality of 5.7%. All these cases were submitted to perineal section and immediate suture of the urethra.

(*c*) Gunshot wounds of the urethra.

In 119 cases Kaufmann found a mortality of 22%. In the 26 fatal cases death was due to hæmorrhage in 3, extravasation of urine in 8, septic inflammation and pyæmia in 14, and scurvy in 1.

Functional results. In the American War of the Rebellion[2] the after-result of 74 cases that survived gunshot wounds of the urethra was as follows: complete healing 10, stricture 26, fistula 38.

The formation of a stricture after rupture of the urethra was an almost invariable result in the cases recorded by the older writers. This result was apparently due to sloughing and septic inflammation.

Where primary union or rapid healing of the urethra is obtained, the canal either remains uncontracted or the stricture which forms is a simple narrow ring, readily amenable to treatment, instead of a tortuous cartilaginous stricture.

In 7 cases operated on by Rutherfurd,[3] the urethra was free from stricture in 5 at periods of sixteen months, seventeen months, three years, three years, and six years respectively after the injury. Two cases developed stricture, which was resected, and no recurrence of the stricture had taken place eighteen months and seven years respectively after the injury.

Cabot[4] records 5 cases of rupture of the urethra treated by immediate suture. No stricture was present from three to five years after the injury in these cases.

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[1] *Die Verletzungen und Verengerungen der Harnröhre,* Berlin, 1902.

[2] *The Medical and Surgical History of the War of the Rebellion,* Washington, 1877, vol. ii, Part II, p. 350.

[3] *Loc. cit.*

[4] *Boston Medical and Surgical Journal,* July 16, 1896, p. 57.

CHAPTER XIX

OPERATIONS FOR STRICTURE OF THE URETHRA

The majority of cases of stricture are cured or relieved by the passage of instruments, but in a certain number of cases a cutting operation becomes necessary.

The recorded opinions of different surgeons vary widely in regard to the necessity for operative interference in uncomplicated stricture of the urethra. While some surgeons, such as Albarran,[1] Goldberg,[2] and Heresco,[3] look upon the operation as one which should be practised, in the great majority of cases, as a preparation or as an aid to the passage of sounds, others—Burckhardt[4] among the number—look upon the incision of a stricture as an operation which is seldom necessary. In Burckhardt's experience 89.8% of all stricture cases are cured by simple dilatation.

Indications. The indications for a cutting operation for stricture are many and varied.

A. Gradual dilatation may have been tried and proved inadequate or unsuitable.

(1) In cases of hard cartilaginous stricture dilatation may be carried up to a certain size and no further progress be made. Urethrotomy is performed and the passage of instruments resumed.

(2) A stricture may be readily dilated, but very quickly relapses to its former size (resilient stricture).

(3) With careful antiseptic precautions and with the most gentle manipulation, rigors may follow each passage of an instrument.

(4) A few strictures bleed at the slightest touch of a bougie. These cases are few, and are not to be confounded with the more frequent hæmorrhages which result from lack of skill or want of care on the part of the operator.

(5) Repeated attacks of epididymitis sometimes interrupt the progress of intermittent dilatation, and, if the stricture be freely cut, relief from these may be obtained.

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[1] *Comptes Rendus XIII^e Congrès Internat. de Méd.,* 1900.

[2] *Deutsche Zeitschr. f. Chir.,* vol. lvii, Nos. 5 and 6.

[3] *Comptes Rendus XIII^e Congrès Internat. de Méd.,* 1900.

[4] Frisch und Zuckerkandl, *Handb. d. Urologie,* 1906, vol. iii.

(6) When recurrent attacks of retention of urine follow the passage of instruments in a stricture of moderately large calibre.

(7) Peri-urethral abscess and extravasation of urine may complicate stricture during the course of intermittent dilatation and necessitate immediate operation.

B. The case may be considered unsuitable for gradual dilatation.

(1) The stricture may be impassable to the finest bougie. In experienced hands these cases are very few in number; but a cutting operation is equally indicated when the stricture on several successive visits will only admit a fine bougie after much difficulty.

(2) In cases of urethral stone, peri-urethral abscess, extravasation of urine, and urethral fistula, operative interference is necessary.

(3) The stricture may be a complication of some disease of the prostate or bladder, such as enlargement of the prostate, stone, tuberculosis, or new growths, and incision of the stricture is the most rapid preparation for a complete examination. Chronic cystitis complicating stricture may be an indication for urethrotomy.

(4) In some diseases of the kidneys complicating stricture of the urethra the most rapid method of completely removing the obstruction is that which is safest.

C. The stricture may be suitable for gradual dilatation, but the patient is unable or unwilling to carry out the treatment.

(1) He may be going abroad beyond reach of medical aid.

(2) He may prefer the cutting operation on account of the longer time required for gradual dilatation.

INTERNAL URETHROTOMY

This operation consists in cutting through the stricture by means of a guarded knife (urethrotome) introduced along the urethra. The stricture may be cut from before backwards—that is, towards the bladder—or from behind forwards; and it may be cut on the roof of the urethra or on the floor.

INTERNAL URETHROTOMY FROM BEFORE BACKWARDS

There are many urethrotomes which cut from before backwards. The principle which underlies these instruments is that a very fine staff is passed through the stricture and acts as a guide along which the guarded knife which is to cut the stricture is pushed.

Maisonneuve's urethrotome (see Fig. 411) consists of a fine curved staff (No. 8 F.) which has a deep groove on the concave surface from the distal to the proximal end. At the point of the staff is a male screw on to which a small bulbous tip screws. This tip may be removed and a fine flexible guide (No. 4 F.) screwed on to the end of the staff by means of a metal end with a female screw. A triangular knife is fixed at one end of a fine steel rod, the other end of which is button-like. The apex of the triangular knife is blunt, smooth, and broad, so that it can glide along the mucous membrane without cutting it. The anterior and posterior edges of the triangle are sharp. A small ring is attached to the shaft near the end, so that it may be steadied by the finger and thumb of an assistant.

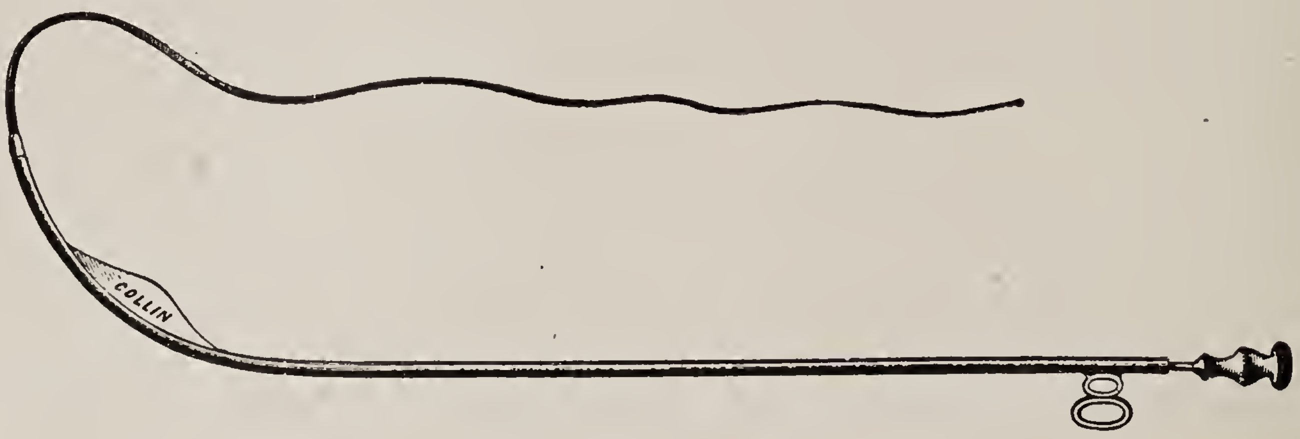

Fig. 411. Maisonneuve's Urethrotome.

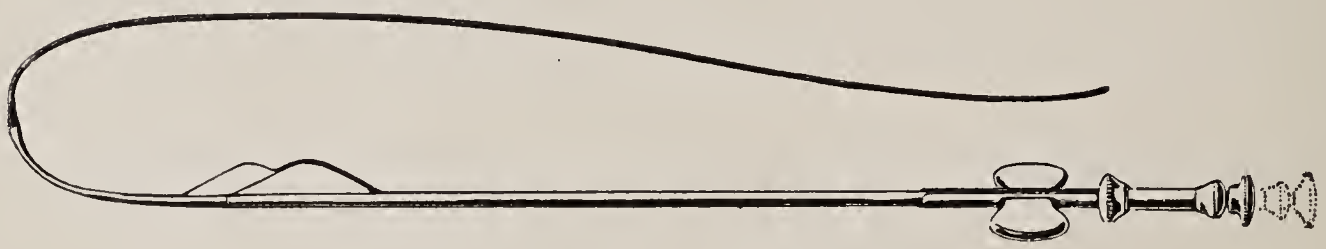

Fig. 412. Teevan's Urethrotome.

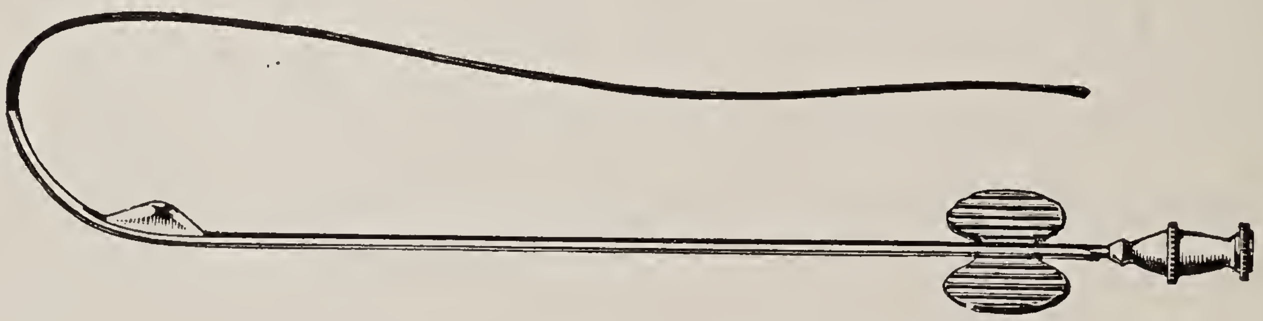

Fig. 413. Author's Urethrotome.

Teevan's modification of this instrument (see Fig. 412) has a thicker staff, and inside the deep groove in this is a second groove. The knife-carrying shaft consists of a triangular sheath attached to a fine tube. Inside this lies the triangular knife and the rod which carries it. The knife is held in place by a spring, and is projected from the sheath by pressing the button end of the knife-carrying shaft, and recoils within the sheath again when pressure is removed. The knife and sheath fit into the grooves in the staff. A cross-piece serves to steady the staff when in position.

Author's urethrotome (see Fig. 413). Without interfering with the simplicity of Maisonneuve's instrument, I have modified it in certain particulars, and the following urethrotome is, I believe, a more serviceable instrument. The filiform guides supplied with Maisonneuve's urethrotome are connected with a bulbous metal tip containing the female screw. This gives an abrupt shoulder which may hitch in a narrow stricture, and, further, the guide is liable to become frayed at this point, and has even broken across and been left in the bladder. In the guides supplied with my instrument the metal junction into which the male screw fits is tapered, and passes for a short distance inside the flexible guide, which thus expands gradually to the thickness of the staff, and there is no abrupt union of flexible bougie and rigid metal. Maisonneuve's instrument has a very wide curve which is different from the curve of the urethra, and the groove for the knife runs as far as the end of the staff. The result is that the instrument fits the urethra badly and that the knife passes into the prostatic urethra when it is pushed to the hilt. In the new instrument the curve is that given to well-made steel bougies and corresponds to the curve of the urethra. The groove passes just beyond the beginning of the curve, so that, when the staff is held in the proper position, the knife will not pass further than the entrance of the membranous urethra. Two large flat transverse wings replace the single vertical ring and provide a good grip for the thumbs and fingers of an assistant. A steel rod fits into the groove in the staff and serves to stiffen it during the introduction of the instrument, and is useful for cleaning it. The rod is removed for the insertion of the knife.

Operation. A general anæsthetic is preferable, but where this is contra-indicated the instillation of twenty minims of a 2% solution of cocaine or a solution of eucaine and adrenalin will suffice, or spinal analgesia may be used. The penis is cleansed and drawn through a small hole in a sheet of sterile lint. The urethra is washed out with a weak antiseptic solution, such as biniodide of mercury (1 in 10,000) or oxycyanide of mercury (1 in 10,000), supplied from a douche can and glass nozzle. The guide should now be introduced, and care is taken that it passes through the stricture and does not double up in front of it. If the stricture be sufficiently large to admit a No. 8 French bougie, the filiform guide may be dispensed with, the small bulbous end screwed on the tip of the staff, and the instrument passed through the stricture.

The surgeon stands on the right side of the patient. In a narrow stricture the fine staff is screwed on to the guide, and the instrument, well oiled, is pushed onwards, taking care that the guide does not double up in front of the stricture. The staff passes through the stricture and lies with the curve in the membranous and prostatic segments of the urethra, the flexible guide coiling inside the bladder.

The staff is held by an assistant at an angle of 45° with the horizontal. He grasps the wings of the urethrotome with a thumb on the upper surface of each and holds the instrument absolutely steady in the middle line. The surgeon dips the point of the triangular knife in sterile oil and introduces it into the groove of the staff. Raising the glans penis with the left thumb and fingers, the knife is slipped past the meatus, and holding the button at the end of the knife rod, is pushed steadily along the urethra until the resistance of the stricture is felt. A sharp push

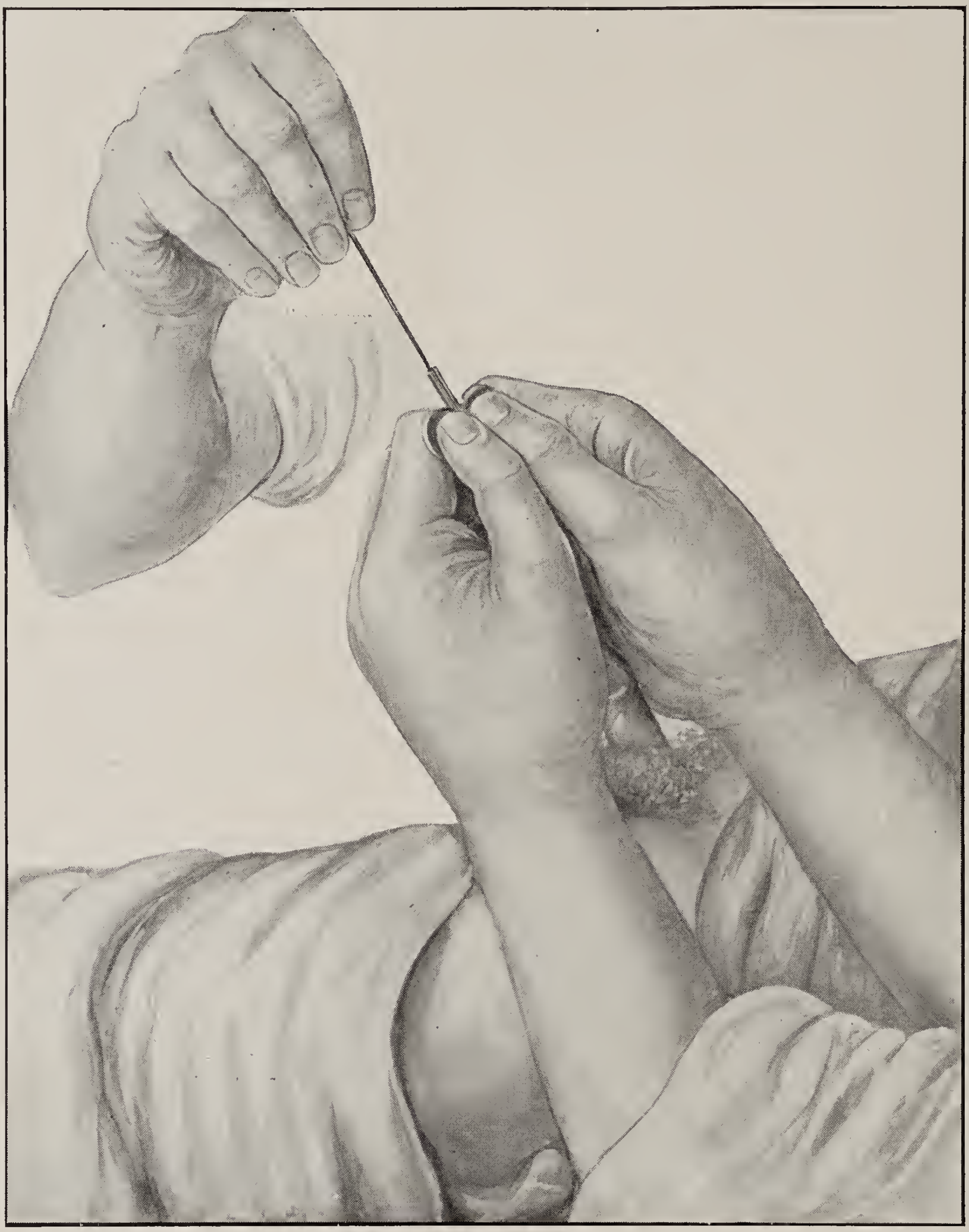

FIG. 414. INTERNAL URETHROTOMY. Staff held in position by the assistant. The surgeon's hand is pushing the blade through the stricture.

cuts the stricture, and the knife slips on and cuts any other strictures that may be present and is finally arrested at the end of the groove (see Fig. 414). The knife is now steadily withdrawn, and when it reaches the stricture on its way out resistance is again felt, and a tug at the rod cuts this through with the sharp reverse edge of the knife. Unless the knife be boldly pushed through the stricture, the fibrous tissue will not be properly cut. The knife rod is withdrawn altogether and the staff and guide then removed.

If Teevan's instrument be used, the procedure is similar until the knife guard is arrested by the stricture. The knife is now projected by pressing the button end and the stricture is cut. On releasing the button the knife springs back under cover of the guard. The knife guard is now pushed onwards through the cut stricture to the next, and when all are cut, the whole instrument may be withdrawn without removing the knife and its guard.

The next step consists in the passage of large steel bougies in order to make certain that the stricture has been cut to the full size. A steel sound of $^{12}/_{14}$ size is passed, and followed by $^{13}/_{15}$ and $^{14}/_{16}$. There is no question here of dilating the cut stricture. If the fibrous ring be not sufficiently cut, resistance to the passage of the instruments will be felt and the urethrotome should again be passed, this time with the bulbous end in place of the filiform bougie, and the knife again run through the stricture. If the meatus be too narrow to admit a large steel instrument, it should be slit downwards by means of a blunt-pointed bistoury introduced into the urethra. Having passed a large steel sound, a coudé catheter (No. 22 F.) is passed into the bladder, and the urine drawn off. If the urine be foul, the bladder should be washed with a weak solution of biniodide or oxycyanide of mercury by means of a large bladder syringe, or a solution of nitrate of silver (1 in 10,000) may be used. The catheter is withdrawn until the eye lies just within the bladder, and tied in. A roll of aseptic gauze is placed around the catheter at the external meatus and is held in position by the tapes that secure the catheter. A syringeful of fluid is injected to ascertain that the catheter eye is in the bladder, a plug is inserted into the end of the catheter, and the patient returned to bed.

After-treatment. The urine is drawn off at frequent intervals by removing the plug from the catheter, or a piece of rubber tubing may be attached and the bladder drained continuously into a urinal. If the bladder be allowed to become distended, the urine may be forced alongside the catheter and come in contact with the urethral wound and the object of the retained catheter is defeated. At the end of forty-eight hours the catheter is removed and the urethra may be washed with an antiseptic lotion. The patient now passes water himself.

If the catheter does not drain efficiently, it is usually due to the instrument having slipped out so that the eye is in the prostatic urethra, or to a clot obstructing the lumen. Pushing the catheter in a little way or the introduction of a syringeful of lotion will re-establish the flow.

INTERNAL URETHROTOMY FROM BEHIND FORWARDS

In this operation an instrument carrying a small knife is passed through the stricture. The knife is then elevated so that it forms an angle with the shaft of the instrument and drawn out, cutting through the stricture. Thompson's modification of Civiale's original instrument (see Fig. 415) consists of a handle, a shaft, and a sheath containing a fine blade. The sheath is wedge-shaped, and flattened at the sides. The calibre corresponds to a No. 5 instrument of the English scale. At the junction of the shaft and handle is a hilt, and about 1 inch from this on the shaft is a small button. While holding the handle in the grasp of the right hand with the thumb pressed against the hilt, the forefinger may be pressed upon the button and the hilt pushed towards it. This draws and elevates a fine blade out of the sheath, and on releasing the hilt the knife again returns to its sheath.

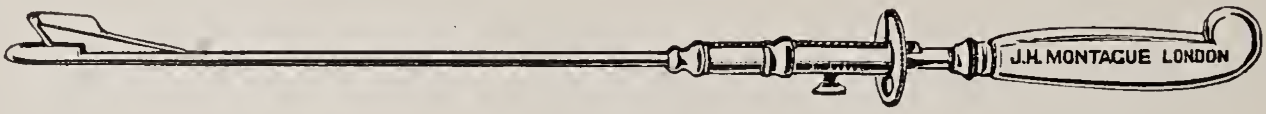

Fig. 415. Civiale's Urethrotome modified by Thompson.

Operation. Before using this instrument the stricture must be dilated to the size of a No. 5 English bougie. The instrument is introduced vertically into the urethra until it has passed through the stricture. It is now withdrawn, still held vertically, until the knife-guard hitches against the back of the stricture. The knife is now elevated in the manner already described and drawn through the stricture with a sharp tug. It is then returned to the sheath, and the remaining steps of the operation and the subsequent treatment carried out in the same manner as after urethrotomy from before backwards.

There are several questions connected with the operation of internal urethrotomy which have given rise to controversy.

Dilatation during and immediately after the incision of the stricture. There are some forms of urethrotome, and that of Otis may be specially mentioned, in which the operation is a combination of cutting and 'bursting' of the stricture. An instrument with two or more blades is passed through the stricture. These blades are separated by a special mechanism, and with the stricture fully on the stretch it is cut with the knife between the separated blades.

Instead of using such an instrument, which necessitates a previous dilatation of the stricture, the stricture may be cut by means of a urethrotome and then dilated by the forcible passage of large bougies. The wound which results from this cutting and tearing operation is ragged and irregular. It is accepted by most modern surgeons that rapid dilatation, or 'bursting' a stricture by the forcible passage of bougies of increasing size rapidly introduced in succession, is likely to give rise to tearing of the submucous tissues and the eventual formation of an irregular and dense scar. The methods just described are a modification of this procedure.

In performing internal urethrotomy the stricture should be freely and cleanly cut, and the passage of a steel instrument afterwards should have the sole object in view of ascertaining whether the stricture is completely severed or whether some uncut strands still remain.

Cutting from before backwards or from behind forwards. So far as safety is concerned no preference can be given to one method over the other. Maisonneuve's blade, which might be looked upon as the more dangerous of the two urethrotomes above described for antero-posterior urethrotomy, pushes up the mucous membrane with the flat apex of the knife as it glides along the staff, and, so long as the mucous membrane is supple and healthy, it is lifted clear of the cutting portion of the blade. Whatever is rigid and tough is not raised up and is cut through. With the guiding staff firmly held at the proper angle there is no danger of cutting too deeply, and with the writer's modification the blade will not enter the membranous urethra.

It is an undoubted disadvantage that the calibre of the stricture must be the size of a No. 5 English bougie before Civiale's instrument can be used for postero-anterior urethrotomy. There is nothing to choose between the two methods in regard to the thoroughness with which the stricture can be cut.

Cutting on the roof or the floor of the urethra. Civiale's instrument cuts the stricture on the floor; the form of Maisonneuve's urethrotome most frequently used cuts on the roof, but it may also be made with the groove so placed that the stricture is cut on the floor. The object of the operation is to cut the fibrous obstruction at its most extensive part. It is stated by some writers that this is always to be found on the floor. Urethroscopic experience does not uphold this view, and in strictures which have so far contracted as to necessitate urethrotomy the greatest development of fibrous tissue is as frequently to be found on the sides or roof of the urethra as on the floor. In the majority of cases which are submitted to internal urethrotomy the fibrous contraction affects the whole circumference of the urethra, and although the lumen is seldom to be found exactly in the centre, there is a considerable depth of fibrous tissue surrounding it on all sides, so that an incision radiating from the lumen to any point in the circumference will sever the ring.

The process of repair of the urethra after incision does not, however, necessitate the selection of the segment in which the greatest amount of fibrous tissue has developed. It is only essential, in the view of the writer, that the circular tension of the ring of fibrous tissue should be abolished, and that the stream of urine, instead of being projected against the back of a tense ring of fibrous tissue with a narrow rigid opening, should flow through a wide opening which has merely loose flaps of tissue at the position of the stricture.

Burckhardt [1] gives the following reasons for insisting that the incision must invariably be placed on the roof: In the bulbous urethra there is less erectile tissue, and the blood-vessels are fewer on the roof than on the floor; the danger of hæmorrhage is therefore less. The mucous membrane of the roof is more fixed and steadier, so that the incision is more accurate. There is less fear of urinary infiltration in a wound of the roof than in one in the floor. Where, however, the stricture is subpubic, the floor is safer than the roof on account of the proximity of the venous prostatic plexus to the latter.

Draining the bladder by a retained catheter after the operation. The catheter must be one or two sizes smaller than that to which the stricture has been cut, for it should not put the stricture wound on the stretch. At the same time a small calibre catheter is to be avoided, for the urine will easily trickle alongside a catheter which lies loosely in the urethra, and there is much greater danger of the lumen of the instrument becoming blocked with a small clot. A No. 20 or 22 French catheter is suitable for most cases, and the eye should be near the end of the instrument. The object of the retained catheter is not to keep the edges of the wound apart and prevent recontraction, as some surgeons seem to suggest.[2] This is sufficiently provided for by the passage of instruments at a later date. By means of the catheter the urine, which is frequently septic and is always poisonous, is prevented from coming in contact with the raw surface of the wound. In the experience of the writer there is less frequently a rise of temperature during the first twenty-four hours after the operation when a catheter is retained than when it is dispensed with. It sometimes happens, as if to demonstrate the efficacy of the catheter, that immediately after the first micturition following its withdrawal the patient has a slight rigor and the temperature shoots up to 101° or 102° and falls again in a few hours.

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[1] Frisch und Zuckerkandl, *Handbuch d. Urologie,* 1906, vol. iii.

[2] Heresco, *Comptes Rendus XIII^e Congrès Internat. de Méd.,* 1900.

The presence of the catheter in the urethra affords a ready means of washing the bladder, which should be taken advantage of when the urine is septic.

Spasm of the bladder sometimes occurs after the operation, and may be due to the use of too strong antiseptic solutions in washing the bladder at the time of the operation, or to the end of the catheter projecting too far into the bladder and continually pressing on its wall. In the great majority of cases a properly placed catheter is borne without discomfort and is efficient in preventing contact of the urine with the wound. A few nervous individuals find the presence of the catheter intolerable, and it is soon dislodged by their constant efforts, so that the urine enters the urethra alongside the instrument. If this occurs, the catheter should at once be removed.

After-treatment. After removal of the catheter the patient is kept quiet in bed for a week and then allowed up. A daily irrigation of the urethra may be given if there be any urethritis, or if the urine be foul, but this is unnecessary if the urine is clear. No instruments are passed for fourteen days after the operation, and then a full-sized steel sound is introduced and usually passes without difficulty. After the first passage of instruments the patient returns in a fortnight for a second, and if the surgeon be satisfied that no recontraction is taking place, the next visit should be paid a month later, then two, three, and six months, and eventually the patient returns at the end of a year's interval, when, if no obstruction to the passage of a large steel instrument is detected, he may be dismissed as cured. Should recontraction of the stricture take place, instruments must be regularly passed at proper intervals.

Difficulties and dangers. 1. *The fine guide of the urethrotome may break* across at the junction with the metal base which unites it to the staff and on withdrawing the instrument it is left in the bladder. If this accident occurs, a small lithotrite should at once be passed and the guide grasped between its jaws and removed.

2. *After the removal of the urethrotome the surgeon may fail to pass a metal sound.* The difficulty is sometimes due to imperfect cutting of the stricture by a blunt knife or to a want of boldness in the cutting stroke. Sometimes an elastic stricture stretches before the pressure of the knife-sheath of Teevan's instrument and thus escapes incision.

The guide of the urethrotome should be replaced by the small metal bulbous tip, the staff reintroduced, and the stricture cut to the full size. Should the surgeon fail to introduce the urethrotome staff, a moderate-sized gum-elastic bougie (No. 12 F.) is the instrument most likely to pass. A Harrison whip-bougie is a useful instrument in this dilemma.

3. *Hæmorrhage.* There is rarely any serious bleeding following internal urethrotomy. At the time of the operation the bleeding is inconsiderable, and for the first two days the urine withdrawn by the retained catheter may be blood-stained. Serious hæmorrhage has, however, occasionally taken place, and a few fatal cases have been recorded. With the more accurate modern urethrotomes such an accident very rarely occurs. No fatal cases occurred among the large number operated upon at St. Peter's Hospital.

When bleeding takes place after internal urethrotomy the foot of the bed should be raised, an icebag containing finely-crushed ice should be placed upon the perineum, and firm pressure applied by means of a large sand-bag. Sand-bags or other support should be arranged so as to prevent the shoulders of the patient slipping towards the head of the bed. If a catheter be in the urethra it should be allowed to remain *in situ,* as it will assist the pressure and allow of the escape of the urine. Without it, bleeding, which has been stanched, tends to recommence on micturition. A hypodermic injection of ergot and opium should be given.

Should these measures fail, the catheter should be removed and the urethra irrigated with hot solution of silver nitrate (1 in 10,000) or a solution containing tincture of hamamelis or adrenalin, and pressure reapplied. If spasm appears to be a factor in the causation of the hæmorrhage, hot fomentations may be tried.

Finally, should the hæmorrhage resist all treatment, a perineal section should be rapidly performed and a large rigid tube introduced into the bladder; around this iodoform gauze should be firmly packed.

Results. 1. *Mortality.* The operation of internal urethrotomy carries with it a remarkably small mortality. In most of the cases where death has followed the operation it has resulted from an exacerbation of pre-existing disease occasioned by the operation and not from any new factor introduced by the operation itself.

I have examined the records of this operation performed at St. Peter's Hospital during a period of thirteen years (1895–1908). In all, 1,316 patients suffering from stricture of the urethra were submitted to operation in the wards of the hospital.[1] The operation of internal urethrotomy alone was performed in 1,018 of these cases. Eight patients died after the operation, giving a mortality of 0.78%.

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[1] This does not include patients treated in the out-patient department of the hospital. I have calculated that 27% of cases of stricture are submitted to operation, and the 1,316 cases will represent this proportion of the total.

The following statistics are to be found in the literature:—

	Number of cases.	*Deaths.*	*Percentage mortality.*
Guyon[1] (1880-90) . . .	1,000	5	0.5
Guyon[2] (1890–1900) . .	980	11	1
Thompson[3]	340	6	2
Lydston[4]	1,500	0	0
Nicolich[5]	235	1	0.4
Desnos[6]	78	0	0
Pousson[7]	500	0	0
Schliffka[8]	16	0	0
Goldberg[9]	7	0	0

Watson and Cunningham[10] have collected the published results of a number of surgeons, some of which are included in the above list. In a total of 4,686 operations there were 53 deaths, a mortality of 1.1%.

Death may follow internal urethrotomy in several ways:—

(*a*) In many cases of long-standing stricture there is chronic cystitis together with chronic septic pyelonephritis. The operation is followed by an acute exacerbation of pyelonephritis, which is fatal. This was the cause of death in four out of the eight fatal cases (50%).

(*b*) Chronic interstitial nephritis complicates prolonged urinary obstruction, and death from renal failure may follow internal urethrotomy performed for the relief of the obstruction (one case).[11]

(*c*) Complete anuria and death from urinary or septic intoxication may occur within a few hours or days of the operation (two cases).

(*d*) Septicæmia or pyæmia may follow the operation without interference with the secretion of urine (one case).

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[1] Desnos, *Annales des maladies des organes génito-urinaires,* 1891, p. 21.

[2] Noguès, *Notice sur l'organisation et le fonctionnement de la clin. d. v. urinaires,* Paris, 1900.

[3] *Stricture of the Urethra,* 1885.

[4] *Med. News,* March 4, 1899.

[5] *Wien. med. Presse,* 1899, 50.

[6] Noguès, *loc. cit.*

[7] *Annales des malad. d. org. génito-urin.,* 1891, p. 206.

[8] *Wien. med. Presse,* 1898, vol. xlvi.

[9] *Deut. Zeitschr. f. Chir.,* 1900, vol. lvii, p. 393.

[10] *Diseases and Surgery of the Genito-urinary System,* 1909.

[11] Thomson Walker, *The Renal Function in Urinary Surgery.* Cassell & Co., 1908.

(*e*) A few cases of death from hæmorrhage have been recorded, after operation with the older forms of urethrotome, where the prostatic plexus of veins was injured.[1]

2. *Healing of the stricture after internal urethrotomy.* The results obtained after internal urethrotomy vary with the character of the stricture. In a well-defined annular stricture in a healthy subject, internal urethrotomy may result in a complete cure. In the practice of the writer this has occurred in a number of cases and the urethra, examined as long as two and three years after the internal urethrotomy, showed no sign of stricture or of the scar of the operation.

In a second group of cases there is a recontraction of the stricture after a period varying from a few months to several years, but the occasional passage of a large metal sound at intervals of several months is sufficient to prevent further contraction.

There is a third group of cases, and this forms a very large proportion of the hospital class of patients, where internal urethrotomy permits of the passage of large instruments at intervals, without which the stricture would rapidly recontract. Irregular attendance, alcoholic indulgence, and other causes frequently produce relapses, so that the cutting operation may have to be repeated and the dilatation resumed. These cases merge into the next class.

The final group is that of cartilaginous stricture, where there is no prospect of cure by urethrotomy or dilatation. This group forms a small proportion of cases treated, and most of them belong to the hospital class of patients. Urethrotomy is performed to enable a good-sized instrument to be passed, and it may be possible by intermittent dilatation to maintain the lumen at this calibre or even with care to increase it. Frequently, however, the stricture slowly recontracts in spite of instrumentation and internal urethrotomy must be repeated and dilatation recommenced.

Internal urethrotomy alone cannot be looked upon as a radical operation for the cure of stricture. Although a certain proportion of cases are cured by this means alone, yet in the majority of cases the passage of instruments must be added to complete the cure or to prevent relapse, and in a small percentage even this combination is insufficient to prevent recontraction of the stricture.

In 100 cases of stricture attending my out-patient department at St. Peter's Hospital 17 had undergone internal urethrotomy. Of these 12 had been operated on once with the following results:—

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[1] Thompson, *Stricture of the Urethra,* 1888 (one case); Fenwick, *Illustrated Medical News,* 1888, No. 3 (two cases).

Time since operation.	*Size of instrument.*	*Attendance.*
A few months	14/16 steel	Regular
A few months	14/16 steel	Regular
One year	13/15 steel	Regular
One year	12/14 steel	Regular
One year	15 F. bougie	Irregular
Two years	12/14 steel	Regular
Three years	13/15 steel	Regular
Three years	12 F. bougie	Irregular
Four years	14/16 steel	Regular
Eleven years	12 F. bougie	Irregular
Fifteen years	10/12 steel	Regular

Five cases required more than one operation.

Number of operations.	*Treatment between operations.*	*Present size.*
Two	Regular dilatation, seventeen years	14 F. bougie
Two	Neglected after first operation	12/14 steel
Five	Irregular dilatation	18 F.
Two	External then internal urethrotomy, neglected	14/16 steel
Two	External then internal urethrotomy	11/13 steel

From these figures it will be seen that a stricture which has been submitted to internal urethrotomy usually contracts again if it is not dilated regularly. If regular dilatation be undertaken the calibre of the stricture remains large.

In a few cases, in spite of regular passage of instruments, the stricture re-contracts and another operation is required, after which regular dilatation may keep the stricture fully dilated.

EXTERNAL URETHROTOMY

The operation of external urethrotomy consists in cutting a stricture by an incision made through the perineum. There are many variations of this procedure and the names of various surgeons have been connected with these.

Choice of method. The principal dividing line in the varieties of external operation upon stricture is the possibility or impossibility of passing an instrument through the stricture before the operation. If an instrument can be passed through the stricture and it is determined to perform external urethrotomy, the operation may be carried out by passing a Syme's staff and cutting the stricture upon this, and the operation is called Syme's operation; or an ordinary grooved staff may pass through the stricture with or without previous dilatation and the incision be made on this; or a staff designed by Morris may be used;

or, finally, a filiform guide may be passed and the urethra opened in front of the stricture on this and the stricture divided upon it. If an instrument cannot be passed through the stricture the urethra may be opened upon a straight staff in front of the constriction and a search made for the lumen of the stricture, and when this is found and a probe passed through it, the stricture is cut from before backwards upon this (Wheelhouse's operation). If the lumen cannot be found the urethra may be approached from behind the stricture by a median perineal incision, using the point of the left forefinger placed in the rectum at the apex of the prostate as a guide (Cock's operation), or the urethra may be exposed behind the stricture by dissection from the perineum and incised, or suprapubic cystotomy may be performed and a sound passed along the urethra from the bladder may be cut upon from the perineum. The stricture may or may not be cut through in this operation. If it be, then a probe or a director should be passed behind forwards and the stricture cut upon this. Finally, the methods of after-treatment vary. A catheter may be introduced along the whole length of the urethra and retained; the urethral wound may be left alone or it may be stitched; or a tube may be placed in the bladder through the perineal wound, or no drainage, either urethral or perineal, may be adopted.

Such are the more important variations of the operation of external urethrotomy. The term perineal section will here be avoided since some confusion has arisen as to its exact application.

EXTERNAL URETHROTOMY WITH A GUIDE

Syme's operation.[1] The operation consists in the passage of a Syme's staff through the stricture and cutting upon this immediately in front of the obstruction, and then cutting through the stricture.

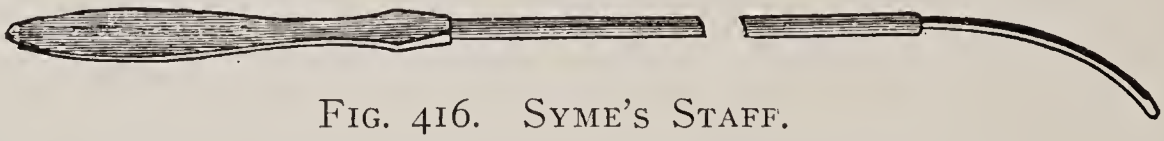

Fig. 416. Syme's Staff.

Syme's staff (see Fig. 416) has a straight shaft and a curved terminal portion. The shaft is equal in gauge to a No. 12 English sound; it terminates abruptly in a shoulder, and the curved terminal portion is equal in size to a No. 4 English sound. A deep groove commences on the shaft about ½ inch behind the shoulder and passes on to the convexity of the fine terminal portion almost to the point of the instrument.

Operation. The operation is performed as follows: The stricture is dilated to the size of a No. 4 English gauge by means of bougies, either by continuous dilatation by tying in a filiform bougie overnight and changing it to a larger instrument, or by the rapid passage of bougies of increasing size. The perineum is shaved and prepared. The patient is anæsthetized and the Syme's staff is passed along the urethra until the shoulder is arrested by contact with the stricture. External urethrotomy is sometimes performed when the stricture is of sufficient calibre to pass a No. 12 English or larger sound. In this case there is no object in using a Syme's staff, and a curved staff with median groove is introduced instead. The patient is now placed in the lithotomy position by means of a crutch or by supports, and an assistant standing at the level of the pelvis on the left side holds the staff vertically exactly in the middle line, grasping the instrument firmly with the right hand, the thumb erect on the upper face of the handle. With his left hand he supports the scrotum vertically. The staff can be felt from the perineum, and an incision is made directly upon it just behind the shoulder, cutting through all the tissues right down to the staff. The urethra may remain undivided in the first incision and the finger can feel the groove in the shaft just behind the shoulder. The point of the knife enters this and is carried along the groove, cutting the stricture in the middle line. The urethra should be cut as far back as the commencement of the membranous portion, and upon this will depend the ease with which the subsequent steps of the operation are performed. In bringing the knife out care should be taken to divide the skin and perineal tissues somewhat more freely than the urethral wall.

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[1] *Edinburgh Journal of Medical Science,* October, 1844.

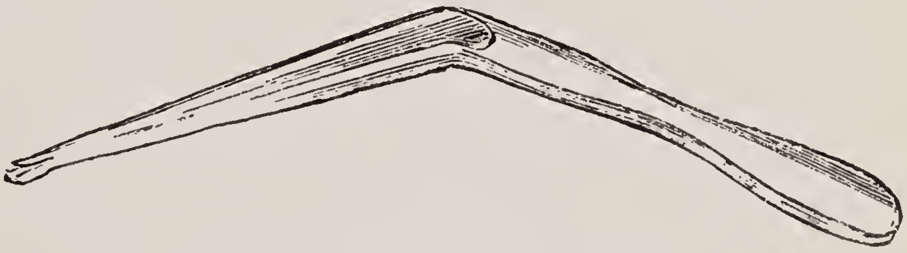

Fig. 417. Probe-pointed Gorget.

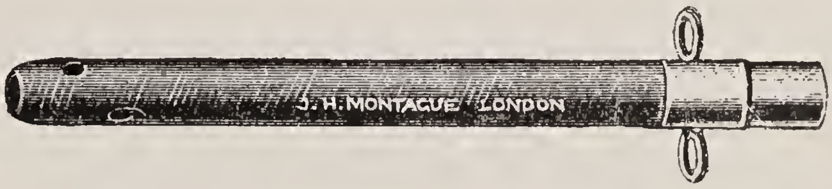

Fig. 418. Perineal Drainage Tube.

The point of a probe-pointed gorget (see Fig. 417) is now introduced into the groove in the staff and pushed onwards into the bladder. The staff is then withdrawn. If the surgeon decides to drain the bladder by means of a catheter, a No. 22 F silk-wove coudé catheter is introduced along the penile urethra and projects into the wound. It is easily directed along the gorget into the bladder and is retained in place by two strips of tape knotted around it, and the ends brought along the penis and fixed to it by means of adhesive plaster. The perineal wound is either left open and a dressing applied, or one or two catgut stitches are placed in the urethral wall and corpus spongiosum, and the rest of the wound left open. The catheter may be changed or left out entirely at the end of three or four days. Instead of tying a catheter in the urethra a large perineal drainage tube may be introduced into the bladder with the help of the gorget. The best form of tube for this purpose is a large-sized rubber tube with smooth rounded end and terminal and lateral openings (see Fig. 418). The tube is guided along the grooved surface of the gorget, which is gradually withdrawn and the tube pushed on through the vesical sphincter. A gush of urine shows that it has reached the bladder. The end of the tube should not project too far into the bladder. The proper position is ascertained by withdrawing it a little and injecting a syringeful of warm boric lotion and watching its return through the tube, and by this means making certain that the eye of the tube lies just within the sphincter of the bladder. A movable metal ring provided with a loop on each side surrounds the tube, and tapes passed through the loops pass up the groins in front and the fold of the buttocks behind, and are attached to a waist-belt. One or two stitches may be introduced at the upper part of the wound and some gauze lightly packed around the tube and a dressing applied. The tube should be removed in four days and a large steel sound passed at the end of a week. Should any difficulty be experienced in passing this into the bladder a small gorget, or a grooved director introduced into the prostatic urethra through the perineal wound, will act as an efficient guide. A large silk-wove catheter should now be passed along the urethra into the bladder and tied in place, and the perineal wound allowed to heal. The retained catheter is removed in four or five days and a large steel sound passed a week later. Sounds should be passed at lengthening intervals after the operation.

EXTERNAL URETHROTOMY WITHOUT A GUIDE

Wheelhouse's operation. When the surgeon has failed to pass an instrument through the stricture the urethra may be opened in front of the narrow part and the opening searched for, and when this is found a fine probe may be passed through it and the stricture slit up upon it. This operation was first applied to this class of case by Arnott [1] in 1822. Wheelhouse [2] slightly modified the technique of the operation and it has been known by his name.

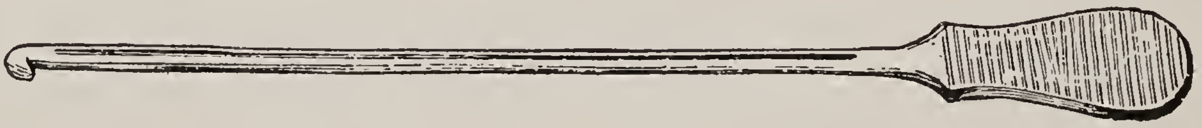

Fig. 419. Wheelhouse's Staff.

Wheelhouse's staff (see Fig. 419) is a straight instrument with a groove which stops short about ½ inch from the end. The rounded end forms a small projection on the side opposite to the groove.

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[1] *Trans. Med. and Chirurgical Soc.,* vol. xii, 1822, p. 351.

[2] *Lancet,* June 24, 1876.

Operation. The patient having been prepared for a perineal operation, Wheelhouse's staff is passed down to the face of the stricture with the groove towards the skin. An incision is made in the middle line of the perineum, which opens the urethra on the groove of the staff, and the tube is slit upward towards the penis for about 2 inches. As the groove does not reach the end of the staff the incision is not carried right up to the face of the stricture, and the relation of the stricture to the rest of the urethra is thus preserved. The staff is now turned round and withdrawn so that the projection at the end hooks up the upper angle of the wound. The mucous membrane of the urethra is picked up with rat-tooth forceps on each side about the middle of the incision, and held out by assistants so that the urethra is fully exposed and slightly stretched. Instead of forceps held by assistants, a fine thread of silk may be passed through the edge of the mucous membrane on each side and this temporarily stitched to the skin. In practice Wheelhouse's staff often works badly as a retractor, and, indeed, it may be altogether dispensed with at this stage of the operation and the upper part of the wound left unretracted or hooked

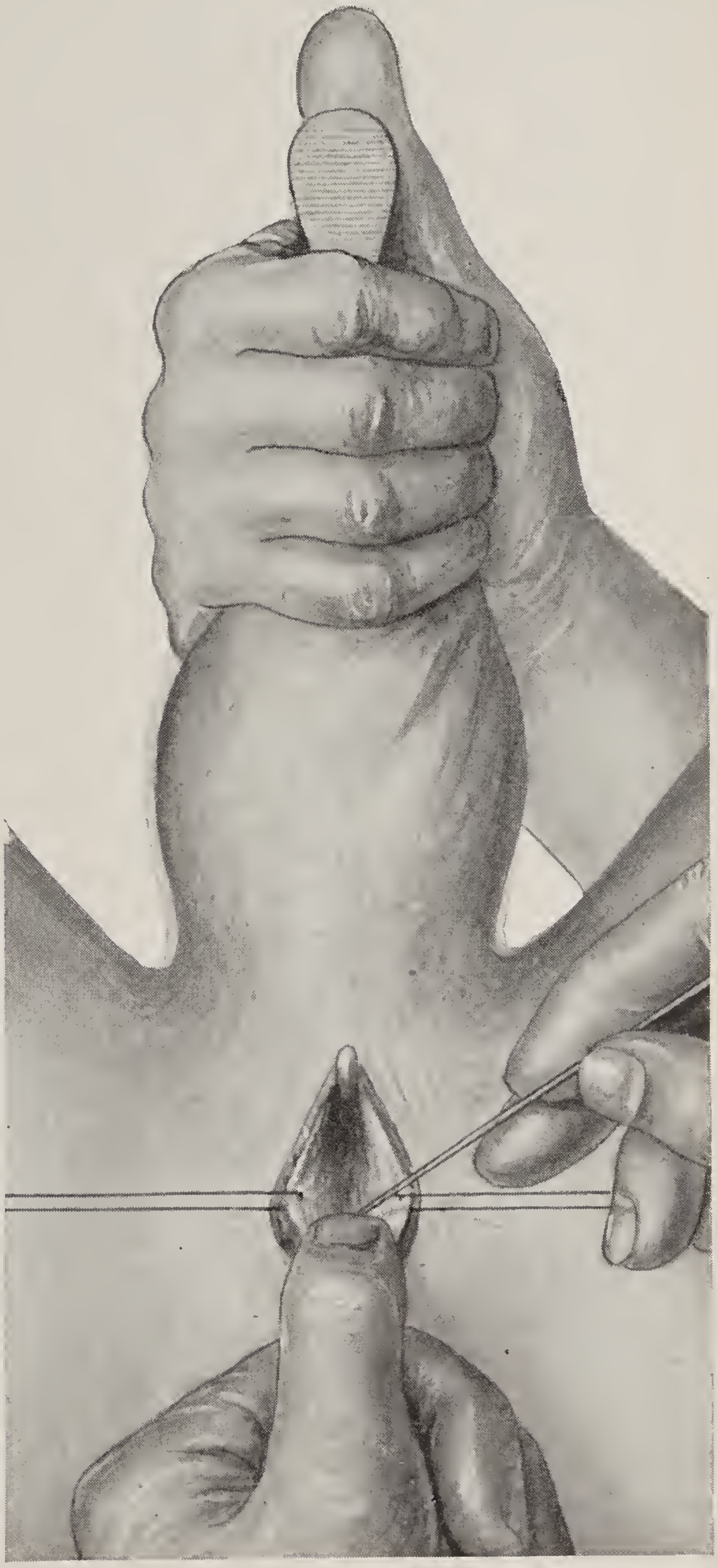

FIG. 420. WHEELHOUSE'S OPERATION. The urethra has been opened and the surgeon is searching with a probe for the lumen of the stricture.

up by a blunt hook introduced from the surface. With a good headlight the surgeon now commences to look for the opening of the stricture, using a fine-grooved probe or a canaliculus director for the purpose. The thumb of the left hand may be placed in the lower angle of the wound and the stricture slightly everted by the fingers pressing on the perineum (see Fig. 420). Every tiny dark spot and depression is carefully probed and searched. The chief difficulty of the operation is the oozing which obscures the field with blood.[1] When this is trickling down from the upper part of the urethra beyond, a small plug of wool or gauze tucked in beneath the staff may control it. But the mucous membrane is often congested and friable and the oozing comes from the whole surface. A plug soaked in adrenalin will greatly assist the operation by blanching the parts and stopping the oozing, but this drug should be used with caution. The writer has experienced very severe post-operative hæmorrhage after a Wheelhouse's urethrotomy, which he attributed to a free use of adrenalin. The search may be prolonged and difficult. If the opening be not found on what appears to be the face of the stricture, the roof of the urethra should be systematically probed in front of this. The small openings of the lacunæ on the roof of the urethra are often deceptive. By making suprapubic pressure a few drops of urine may be made to escape from the lumen of the stricture, and betray its situation. It may happen that Wheelhouse's staff enters a very large old-standing false passage with a smooth lining, and as such a diverticulum is usually found on the floor, the opening of the stricture will be somewhere along the roof of this. The writer found in one case, where the search had to be abandoned and the urethra exposed by dissection behind the stricture, that a probe passed backwards through the stricture emerged in the urethra 2 inches in front of what was apparently the face of the stricture. The point at which the probe appeared was beyond the upper angle of the urethrotomy wound, and the staff had sunk for 2 inches into a large smooth-walled false passage below the stricture.

Having found, by diligent probing, the opening of the stricture lumen, the remaining steps of the operation are easy. The probe is passed through the stricture and the point of a knife follows this guide and cuts the stricture completely through on the floor. The portion of the urethra behind the stricture is usually dilated and a director or a gorget is readily passed into the bladder. A large catheter is now passed along the penile urethra and is guided into the bladder by means of the gorget. The perineal wound may be left without suturing, or one or two catgut sutures may be inserted to draw the edges of the urethra and the perineal tissues together. The catheter is tied in place and retained for four days, when it is removed. Some urine will probably escape from the perineal wound, if not during the retention of the catheter then immediately after its removal, but this ceases and in a few days the wound is dry. The passage of steel sounds is commenced ten or fourteen days after the operation.

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[1] For this reason it is wise not to commence a Wheelhouse's operation at the end of a prolonged attempt to pass instruments. The operation should be postponed for a week or longer so that any oozing from laceration of the mucous membrane will have ceased.

Modifications. When the surgeon fails after a prolonged attempt to find the opening of the stricture several methods of procedure are open to him. It has been recommended that the stricture tissue should be incised in the middle line until the lumen is reached. This method is not, however, likely to be successful in discovering the proper lumen of the stricture, although the urethra behind it may thus be opened. The new lumen that is formed in this way will pass through the fibrous tissue of the stricture and is very liable to recontraction.

If Wheelhouse's operation fails, one of three procedures may be adopted. 1. The urethra may be exposed behind the stricture by dissection and here opened. This is done by continuing Wheelhouse's incision backwards towards the anus, or, if the first median incision is far forwards, by making a second incision in front of the anus over the posterior extremity of the bulb, or a curved prerectal incision may be made so as to give free exposure for a careful dissection. In practice the latter incision is seldom necessary. The bulb is first exposed, and on reaching the posterior extremity of this the urethra is easily exposed at its membranous portion, since it is usually considerably dilated at this part. A probe is now passed penis-ward through the stricture and the scar tissue slit up from behind forwards upon this. A gorget or director is passed into the bladder and serves as a guide for a catheter passed as before.

2. The second method of procedure which has been practised in this dilemma is the so-called Cock's operation of perineal section without a guide.

Cock's operation. The forefinger of the left hand is introduced into the rectum and feels for the prostate. The pulp of the finger is placed upon the apex of that organ. A Cock's double-edged knife is now entered in the middle line of the perineum about ½ inch in front of the anus, the handle being held strictly in the horizontal plane. The knife is pushed onwards until its approach is felt by the rectal forefinger and it has reached the apex of the prostate. The urethra will now have been opened and the knife may be withdrawn, rocking it a little upwards and downwards so as to extend the superficial part of the wound. A probe-pointed director is now introduced into the wound and pushed on into the bladder, and this serves as a guide for the introduction of a perineal tube.

This operation was introduced by Cock for cases of acute retention in impassable stricture as an emergency operation. It was also used in cases where the perineum was much distorted by fistulæ and fibrous tissue. It has no advantage over the operation just described, and has the very grave disadvantage that it leaves the stricture untreated.

3. A third plan is to perform suprapubic cystotomy and retrograde catheterization. The bladder is usually distended with urine in the cases where this procedure is required, so that it is easily exposed and opened. After opening the bladder suprapubically, a metal sound is passed along the urethra from behind forwards. Fuller[1] recommends the use of a Bénique's sound, which, on account of its full curve, is well suited for this purpose. It is made prominent in the perineum at the posterior surface of the stricture. The patient is then raised into the lithotomy position and the point of the sound is cut upon in the middle line of the perineum. An attempt can now be made to pass a probe forwards through the stricture so that it may be cut from behind forwards. If the probe cannot be passed through the stricture a sound should be passed down to the front of the stricture and the cicatricial tissue cut through in the middle line until this is exposed. The bladder is drained either through the perineal wound or through a catheter introduced along the urethra through the cut stricture and secured in position. The suprapubic wound is allowed to close. This operation is seldom necessary and has little to recommend it over the other methods just described.

Dangers. 1. *Hæmorrhage.* Severe hæmorrhage may arise either from the erectile tissue of the corpus spongiosum or from some vessel deeper in the perineum or at the neck of the bladder. The hæmorrhage may occur within a few hours of the operation, or it may commence eight or ten days later.

When hæmorrhage occurs the perineal wound should be opened up, and by turning out the clots some idea will be gained as to the probable source. A stream of hot lotion from an irrigator and a good head-light will greatly assist the search. Any vessel which is obviously bleeding is picked up. If a perineal tube be already in the bladder, strips of gauze should be packed around this. If a tube has not been tied in it should now be passed with the help of a gorget and the wound packed. A broad T-bandage allowing for the exit of the tube provides firm pressure on the perineum.

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[1] *Diseases of the Genito-urinary System,* 1900, p. 290.

The remaining dangers of the operation are due to an exacerbation of previous disease as a result of the operation.

2. Cystitis and septic pyelonephritis.
3. Renal failure and uræmia.
4. Spread of septic inflammation in the pelvis or perineum.

Results. *Mortality.* It is hardly possible to quote figures which will give an accurate idea of the mortality of this operation compared with internal urethrotomy. For this there are several reasons.

(i) The individual surgeon practises one of these operations almost to the exclusion of the other, and if he favours internal urethrotomy the external operation will be reserved for the most serious cases.

(ii) The statistics which are given for internal urethrotomy are largely those of stricture without local complications; those of external urethrotomy include a very large proportion of complicated cases.

The figures which follow must therefore be considered in that light.

At St. Peter's Hospital external urethrotomy or perineal section was performed in 100 cases with 8 deaths during a period of 13 years (1895 to 1908), and the patient died of the results of pre-existing disease, such as extravasation of urine and septic inflammation, in most of these cases.

The following statistics appear in the literature:—

Grégory[1]	992	cases	Mortality	8.8%
Martens[2]	64	“	“	14.0%
Horwitz[3]	116	“	“	4.3%
Novotny-v. Antal[4] . .	80	“	“	3.75%
Burckhardt[5]	25	“	“	12.0%
König[6]	40	“	“	0 %
Gross[7]	26	“	“	3.8%
Syme[8]	105	“	“	0.2%
Thompson[9]	219	“	“	6.5%
Nicolich[10]	20	“	“	0 %

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[1] *Thèse de Paris,* 1879. This author states that the deaths which might directly be attributed to the operation amounted to 3.02%.

[2] *Die Verletzungen und Veränderungen der Harnröhre,* Berlin, 1902.

[3] *Journ. of Cutan. and Genito-urinary Disease,* 1898, p. 362.

[4] *Centralbl. f. d. Krankh. d. Harn- und Sex.-Org.,* ii. 336.

[5] Frisch und Zuckerkandl, *Handb. d. Urologie,* 1906.

[6] Quoted by Güterbock, *Krankh. d. Harnorgane,* vol. i, pt. 1, 1890.

[7] Quoted by Güterbock, *loc. cit.*

[8] *Stricture of the Urethra,* 1849.

[9] *Stricture of the Urethra,* 1885.

[10] *Wien. Med. Presse,* 1890, No. 50, 2083.

Results. There is no greater certainty of curing a stricture by means of external urethrotomy than by other methods. The writer has met with a case in which no contraction of the urethra could be found with the urethroscope aided by air-distension two years after a Wheelhouse's operation. Most authorities agree that such cases may follow external urethrotomy. Post, van Buren, and Sayer[1] have seen patients twenty, twenty-one, and twenty-five years after external urethrotomy and found no recurrence. But the proportion of these cases is remarkably small when a large number of operated strictures is examined.

Where instruments are passed regularly after the operation the results are much better, and cases where a large instrument ($^{12}/_{14}$ or $^{14}/_{16}$ steel) is passed at intervals of some months and no recontraction is apparent are not infrequently observed.

Where the patient neglects regular dilatation, and where exposure and alcoholic excess are superadded, recontraction of the stricture becomes a certainty and it will become hard and cartilaginous in character.

There are cases, however, in which, notwithstanding regular habits and periodic instrumentation, the stricture slowly contracts after the operation, and a second cutting is required. In 100 cases of stricture attending my clinic at St. Peter's Hospital, external urethrotomy had been performed in twelve.

In 5 cases external urethrotomy had been performed once.
In 2 " " " " " " twice.
In 1 case " " " " " 5 times.
In 1 " " " " " " 6 times.
In 3 cases external urethrotomy was followed by internal urethrotomy at a later date.

The five cases where external urethrotomy had been performed once were those in which the best result had been obtained. Of these a No. 22 French bougie could be passed six months after the operation. Two patients could take a $^{13}/_{15}$ steel and a No. 19 French bougie respectively four years after the operation. One patient took a No. 16 French bougie nine years after the operation, and one a No. 10 French bougie seventeen years after the operation. In all these patients bougies had been passed regularly since. The attendance of the patient whose stricture took only a No. 10 French bougie was irregular. Two of these patients (Nos. 10 F. and 16 F.) would require a cutting operation again. In the patients who required a repetition of the operation, or have submitted to internal urethrotomy, there was invariably a history of neglect to have instruments passed after the operation.

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[1] Quoted by Heresco, *Comptes Rendus XIII^{e} Congrès Internat. de Méd.*, 1900.

These figures point to the conclusion that, although a few cures may be effected by means of external urethrotomy alone, the great majority require the regular passage of instruments after the operation, and any neglect of this will court recontraction.

EXCISION OF STRICTURES

A single stricture of moderate dimensions may be resected and the urethra united by sutures. The following is the technique of the operation:

Operation. The suprapubic and perineal regions are carefully prepared for operation. A preliminary suprapubic cystotomy is performed and a rubber tube fixed in position above the pubes. The patient is then placed in the lithotomy position and a metal instrument passed through the stricture. In the cases which are suitable for the operation the stricture can usually be felt from the surface of the perineum.

A median incision is made for about 2 inches with the stricture area as a centre. The corpus spongiosum is exposed and its sheath incised to the full extent of the wound. Careful dissection now exposes the hard fibrous tissue of the stricture, and it may be so well defined as to be easily separated from the surrounding structures as a thick ring of yellowish white, almost cartilage-like tissue. This is carefully separated for the whole circumference of the urethra. In some strictures, and especially in those of traumatic origin, the fibrous tissue extends for some distance into the cavernous tissue of the bulb. The isolated ring of fibrous tissue is steadied while the urethra is cut across transversely in front and behind it. In order to carry this out the instrument which lay in the urethra may have to be removed. The cut ends of the urethra are now dissected up, and are freed so far as will allow the opposite edges to come in contact without the slightest tension being put upon the wall of the tube. A series of fine catgut stitches, commencing at the dorsum, is now introduced to bring the edges into apposition. The stitches pierce the whole thickness of the wall, and the edges of the mucous membrane are apposed as accurately as possible. After the first stitches are inserted, an instrument should again be introduced, and the rest of the stitching done with this as a splint. A gum-elastic bougie is more suitable than a metal instrument for this purpose. Having completed the suture, the bougie is removed and the structures superficial to the urethra are brought together with catgut sutures and the skin wound closed with silkworm-gut. Care should be taken that the oozing from the corpus spongiosum and any other bleeding is stopped before closing the wound.

The suprapubic wound is drained by means of a suction apparatus for seven or ten days, when the tube may be removed. The foot of the bed should be raised so as to keep the urine as much as possible from the neck of the bladder.

A month after the operation the urethra should be examined with the urethroscope and a large steel bougie passed. If contraction has occurred at the site of suture regular dilatation should be commenced.

Some points are open to discussion.

(i) Most authorities on this subject recommend a retained urethral catheter, and do not drain the bladder suprapubically. The writer is strongly of the opinion that in order to attain a reasonable certainty of success in plastic operations upon the urethra suprapubic drainage must be used. The retained catheter, he believes, produces after forty-eight hours a certain amount of inflammation of the urethra, which is detrimental to healing, and after this time it is not a reliable method of bladder drainage, for it allows urine to trickle alongside it and soak the line of incision. Suprapubic drainage is a much more certain method of safeguarding the wound from infiltration of urine, but even with an open suprapubic wound a few drops of urine may sometimes find their way into the prostatic urethra and be forced out of the external meatus. It is essential therefore to keep the bladder as dry as possible.

(ii) Catgut sutures are suitable for this work, and may be left to absorb or to come away in the urine later on partly absorbed, or are removed through the urethroscope. Buried sutures of fine silk are recommended by some surgeons. They must be inserted so that they do not pierce the mucous membrane of the urethra (Pousson,[1] Berg,[2] Thomas[3]).

(iii) The extent of tissue which has been removed from the urethra wall has varied. Sometimes only a part of the circumference of the stricture is removed and the healthy mucous membrane stitched transversely. Guyon[4] operated upon a traumatic stricture in this manner. The writer resected a portion of a ring-like stricture of the penile urethra in the same way, and obtained primary healing. A steel bougie (12/14) passed easily before the patient left the hospital three weeks after the operation. Unfortunately all trace of the patient was lost.

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[1] *Bull. et Mém. de la Soc. de Chir.*, 1896, p. 517.

[2] *Annals of Surgery*, 1903, No. 4.

[3] *Brit. Med. Journ.*, November 8, 1902.

[4] *Annales des maladies des organes génito-urinaires*, April, 1894.

An inch or an inch and a half of the urethra may be removed, and if the tube is freed for a sufficient distance on each side of the section, no tension is produced on uniting the ends. Burckhardt[1] has resected a length of urethra 6 centimetres (about 2¼ inches), and Goldman[2] excised a portion measuring 8 centimetres (about 3⅛ inches). In the latter case the urethra was separated from the corpus cavernosum almost as far forward as the corona glandis. There was subsequent forward curving of the penis on erection, but this gradually disappeared. If the extent of urethral wall removed be such that after free preparation of each end of the urethra the ends will not meet without tension, some form of plastic operation will be required to make good the defect (see p. 798).

Results. The cases collected by Nogués[3] and Vignard[4] show that resection of stricture of the urethra in suitable cases is a successful operation, and that permanent cure of the stricture can thus be obtained. In fifteen cases there was no recurrence at the end of periods varying from six months to eight years.

Heusner[5] resected the stricture in a patient who died two and a half years later of kidney disease. At the autopsy only a linear scar was found at the site of resection.

A patient described by Horteloup[6] died three and a half years after the operation, and it was found that the perineal cicatrix was supple and there was no difference to be seen between the mucous membrane at the resected portion and that of the rest of the urethra. Tonnesco[7] describes two cases of resection where no recurrence of the contraction was observed one and a half and two years after the operation.

Rutherfurd[8] resected two traumatic strictures, removing ⅜ and ½ inch of the urethra and suturing the ends. One patient had a full-sized urethra seven years, and the other twelve months after the operation.

Watson and Cunningham[9] collected 64 cases of resection, but in only 13 of these was there any information in regard to the condition of the urethra more than a year after the operation. Of these the statement in 5 was only that the urinary stream or the urethral calibre was normal. In 3 cases the calibre one year after operation was 24, 26, and 27 respectively; in 3 cases examined fourteen months, fifteen months, and two years after operation, the calibre was 18, 22, and 23; and in 2 examined three, six, and one and a half years after operation, the calibre was 24 and 26.

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[1] Frisch und Zuckerkandl, *Handb. der Urologie.*

[2] *Beitr. z. klin. Chir.*, 1904, vol. xlii, 230.

[3] *Loc. cit.*

[4] Quoted by Heresco, *Comptes Rendus XIII^e Congrès Internat. de Méd.*, 1900.

[5] *Deut. med. Wochenschr.*, 1883, No. 28.

[6] *Bull. et Mém. de la Soc. de Chir.*, Paris, 1882.

[7] Quoted by Heresco, *loc. cit.*

[8] *Lancet*, September 10, 1904.

[9] *Loc. cit.*

THE SELECTION OF AN OPERATION IN STRICTURE OF THE URETHRA

Where a cutting operation becomes necessary the choice rests between internal and external urethrotomy and excision.

The following points may be considered:—

(i) *Position of the stricture.* A penile stricture is unsuitable for external urethrotomy, for a fistula is likely to follow the operation. Internal urethrotomy, either by Maisonneuve's or by Civiale's instrument, is preferable. The passage of instruments after operation must be commenced early in these strictures. If the stricture be near the meatus, a long thin blunt-pointed bistoury can sometimes be introduced along the urethra, and the stricture cut on the floor. Resection of a single well-defined stricture in this region may be successful.

Stricture in the bulbous urethra is suitable, so far as position is concerned, for any of the operative methods.

(ii) *Character of the stricture.* Soft annular strictures are specially suitable for internal urethrotomy followed by instrumental dilatation.

In a hard cartilaginous stricture internal urethrotomy will allow of a large (14/16) steel sound being introduced, and the progress depends upon the after-treatment by instruments. In similar manner the stricture will relapse after external urethrotomy if the regular dilatation by instruments be neglected. The writer has not met with a stricture too hard to be cut with a Maisonneuve instrument if the blade be keen. If the stricture be circumscribed and of cartilaginous hardness, and traumatic strictures specially conform to this type, resection of the stricture and immediate suture of the urethra may be performed and will be more likely to give a permanently successful result.

Multiple strictures of the urethra, which form much the greater number of strictures (73% in the writer's cases), are unsuitable for external urethrotomy and for excision. Internal urethrotomy is the operation of choice in this type.

(iii) *Thoroughness of the operation.* If excision of the stricture be feasible, it is the most thorough of the three operations, but the fact that the great majority of strictures are multiple limits the application of this method.

External urethrotomy cuts through a much greater depth of tissue than internal urethrotomy. But with the exception of the cases of strictures which are complicated with fistulæ or are traumatic in origin, the urethrotome will cut to a sufficient depth to sever the whole of the stricture tissue. It is an almost invariable rule that in multiple strictures of the urethra the narrowest stricture lies nearest the bladder. In external urethrotomy this stricture is cut, but the strictures of wider calibre which lie nearer the external meatus are neglected. On this account the writer invariably performs a combined internal and external urethrotomy where an external operation is considered necessary. This combined operation was introduced by the late Mr. Reginald Harrison[1] in 1885, 'with the object of providing better drainage for urine and the discharges from a wound (internal urethrotomy), which can only be imperfectly treated antiseptically.'

(iv) *The duration of the convalescence.* To some patients it is an important consideration that after internal urethrotomy they can get about at the end of a week or ten days, while after external urethrotomy and resection they are confined to bed for fourteen to twenty-one days, or sometimes longer.

(v) *Danger of the operation.* In the mortality tables that have been given the danger of external urethrotomy appears to be far greater than internal urethrotomy. These figures are deceptive, however, for the cases submitted to external urethrotomy include the worst types of stricture and those complicated by abscess and extravasation of urine. External urethrotomy is probably somewhat more dangerous to life than internal urethrotomy, but not to the extent shown in these figures.

(vi) *After-results.* Recontraction of a stricture takes place after both internal and external urethrotomy, and probably in about an equal number of cases, and in about a similar time. The fact that in multiple stricture only the narrowest stricture is cut makes a relapse more likely in external urethrotomy.

(vii) *Stricture with complications.* A stricture with local complications, such as peri-urethral abscess, fistulæ, extravasation of urine, or urethral calculus, is best treated by external urethrotomy, and the combined operation of Harrison is useful in many cases.

Where chronic cystitis is present and thorough bladder drainage is desired, a large tube introduced through a perineal wound is a better method of obtaining it than a retained urethral catheter.

Where stone in the bladder is complicated by stricture and litholapaxy is the method of treatment which the surgeon proposes to adopt, internal urethrotomy should be performed in preference to perineal section as a preliminary to the major operation.

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[1] *Brit. Med. Journ.*, July 18, 1885.

CHAPTER XX

OPERATIONS FOR THE REPAIR OF FISTULÆ AND ACQUIRED DEFECTS OF THE URETHRAL WALL

THE following preliminary statements may be made:—

1. Any urethral complication which accompanies the fistula must be rectified before attempting to repair the urethra. Thus a stricture must be freely cut and fully dilated before the urethroplasty is undertaken, and urethral calculi, which frequently complicate fistulæ, must be removed.

2. Efficient drainage of the bladder must be provided so as to avoid contact of the urine with the operation wound which closes the fistula. Suprapubic cystotomy is the only means of drainage that presents a reasonable certainty of success in plastic operations upon the urethra. Suprapubic drainage is therefore a necessary preliminary to the methods of treatment here described.

3. No attempt should be made to close a fistula while acute or subacute inflammation is present, and this especially applies to the fistulæ which follow the rupture of a peri-urethral abscess.

The operations will be considered according to the position of the fistula.

FOR FISTULÆ OF THE PENILE URETHRA

AT THE BASE OF THE GLANS PENIS

The following operation was described by Dieffenbach:[1]

Dieffenbach's operation. The edges of the fistula are excised by a transverse elliptical incision (see Fig. 421, A) and the raw edges united by fine catgut sutures. Fine silk may be used and should be tied with the knot inwards. The ends of the sutures are drawn out through the external meatus and may be removed by gentle traction a few days after the operation. The under surface of the glans penis is now denuded of epithelium and a corresponding area is marked out by an incision on the under surface of the penis or the retracted foreskin, the two surfaces being base to base (see Fig. 421, B). The skin is dissected up from the foreskin or penis and turned forwards like a gangway, so that it covers over the freshened surface of the glans, and is stitched in this position (see Fig. 421, C). A similar operation has been described by Loumeau, but, instead of turning over a flap of skin, an incision is prolonged downwards from each of the lower angles of the denuded area and a flap of skin is dissected up. This flap is pulled up over the raw area and stitched in position.

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[1] *Operative Chirurgie,* vol. i, p. 538.

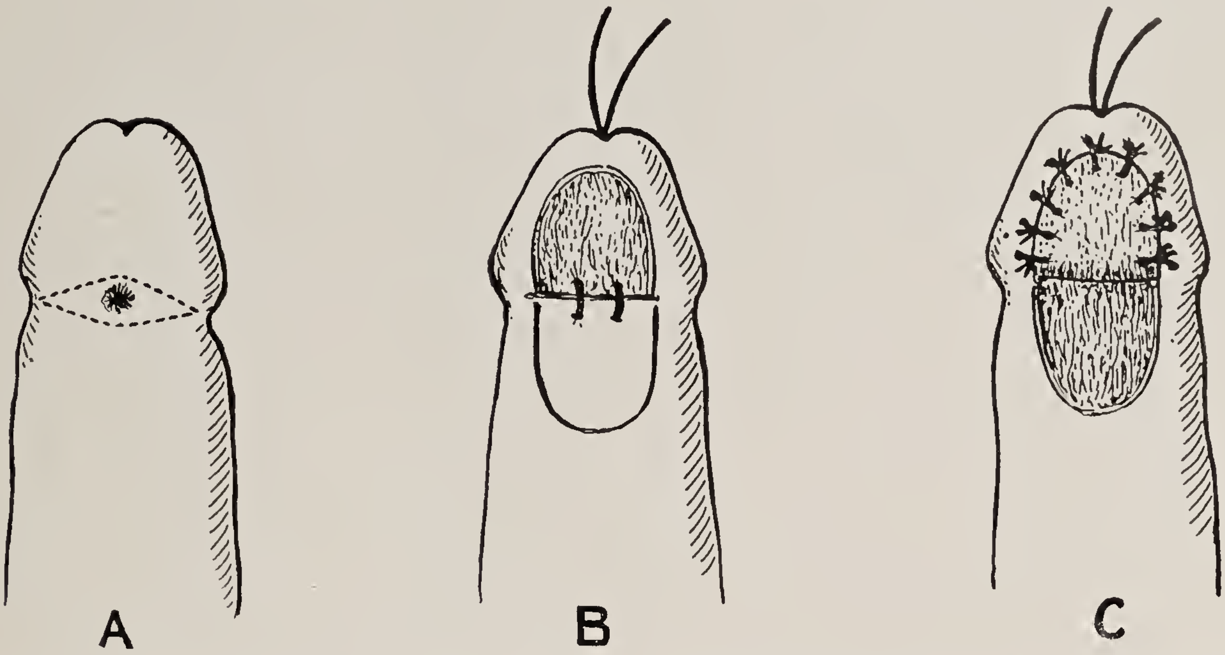

FIG. 421. DIEFFENBACH'S OPERATION FOR THE REPAIR OF PENILE FISTULA.

ON THE UNDER SURFACE OF THE BODY OF THE PENIS

Operation. The following method has been adopted by the writer in several cases and has invariably proved successful: The skin and urethral mucous membrane are always united at the edges of a fistula in this position, and the intervening layers of tissue in the lips are very thin. With a fine knife the skin and mucous membrane are separated all round the edge of the fistula and the skin properly freed for some distance around (see Fig. 422, A). The mucous membrane is also freed. A series of fine catgut stitches is introduced, so that the mucous membrane is united transversely, and the tissues over this are drawn together by a second series of catgut stitches in the long axis of the penis (see Fig. 422, B). Finally the skin is united in the long axis of the penis with silkworm-gut (see Fig. 422, C). Healing by primary union usually follows. A very small opening may occasionally remain from the breaking down of one part of the wound, but this should heal spontaneously in a few days. No catheter is tied in, for temporary suprapubic drainage has been established.

Where the fistula is large and there is difficulty in obtaining apposition of the skin without tension, a longitudinal incision may be made through the skin on each side of the fistula. The edges of the fistula are now excised and the urethra stitched and the bridge of skin slipped

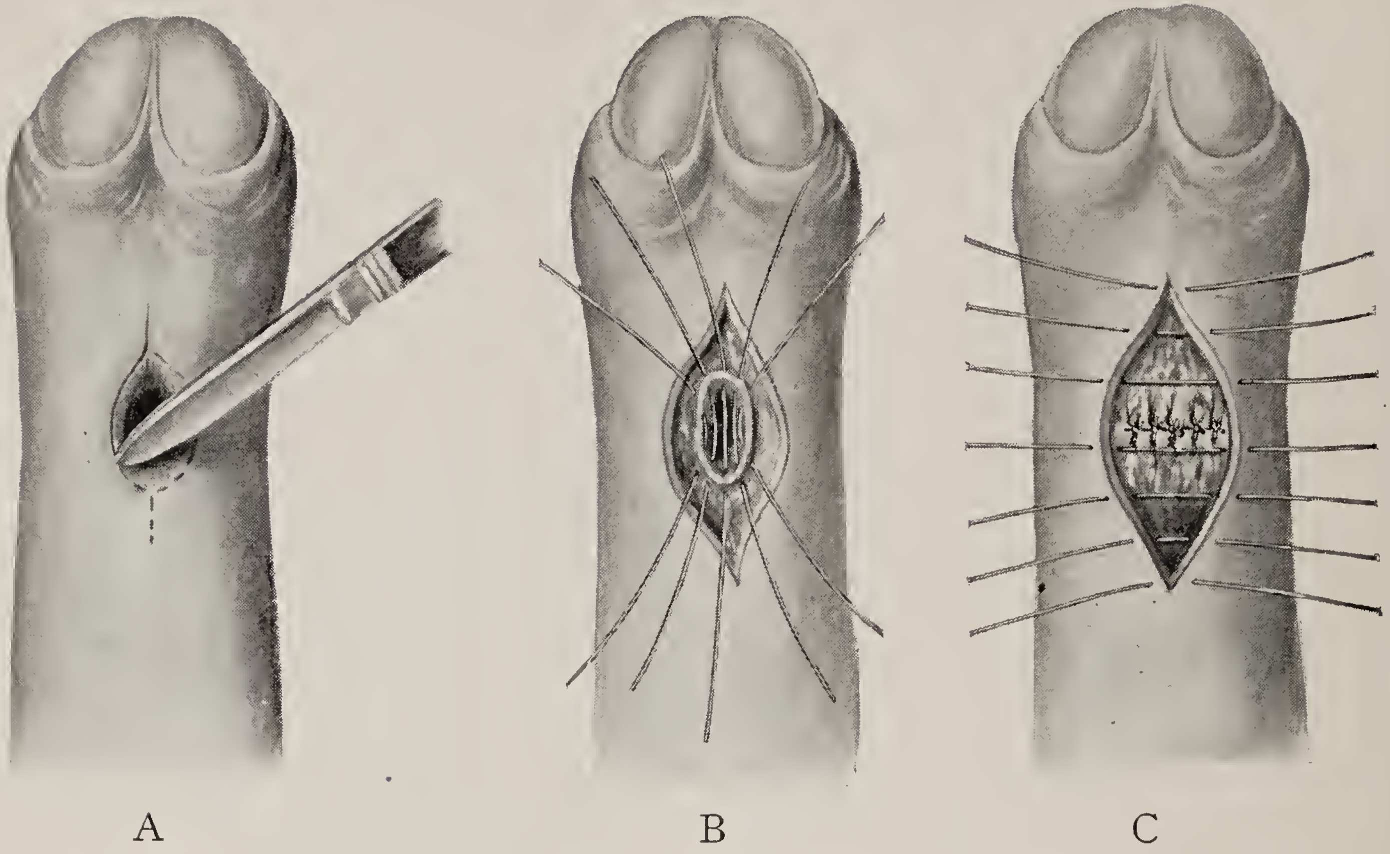

Fig. 422. Operation for Penile Fistula.

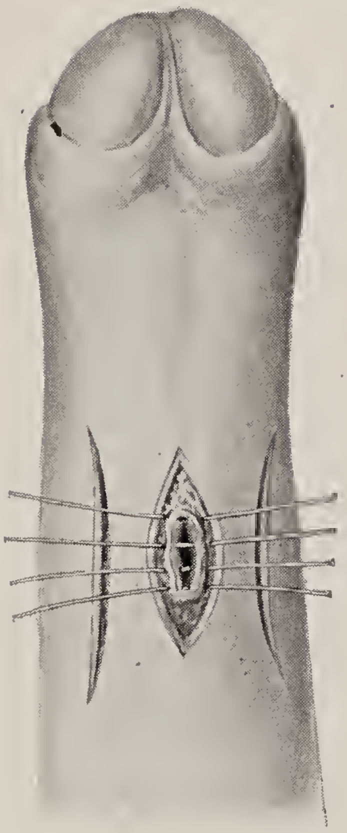

Fig. 423.
Lateral Bridge
Operation for
Penile Fistula.

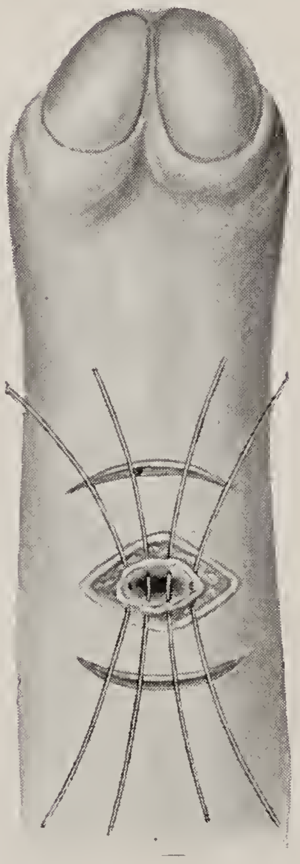

Fig. 424.
Transverse Bridge
Operation for
Penile Fistula.

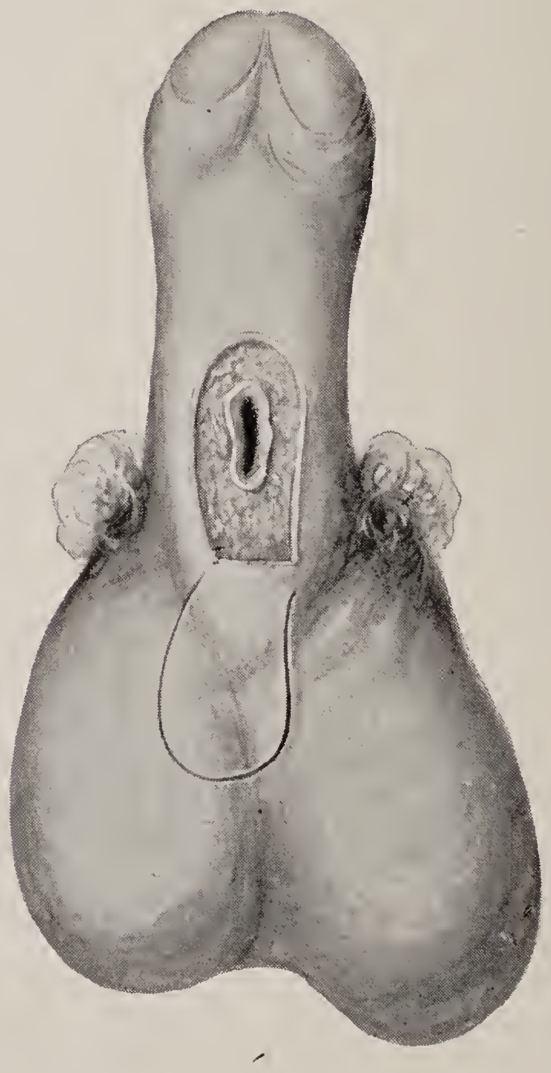

Fig. 425.
Skin-flap Operation for
Penile Fistula.

over the wound from each side and united over the closed fistula (see Fig. 423). Or a transverse incision may be made below the fistula and the transverse bridge thus obtained slipped forwards over the fistula (Dieffenbach); or a double transverse bridge of skin is used from above and below the fistula (Nélaton) (see Fig. 424), or a flap of skin may be turned over from the anterior surface of the scrotum to repair the defect after excision of the fistula (see Fig. 425). Guyon and Pasteau closed a large penile fistula by raising a flap of skin on either side. A longitudinal flap was raised from the skin below the fistula and left attached at its base. This flap was then turned over so that the skin surface formed the floor of the urethra at the fistulous opening. The lateral flaps were now brought together over this and the raw surfaces left by turning up the flap closed by stitches.

FOR FISTULÆ OF THE BULBOUS URETHRA

These fistulæ are almost invariably combined with stricture of the urethra and sometimes also with urethral calculus. The preliminary steps to the operation upon the fistula consist in an internal urethrotomy and, if a stone is present, in its removal.

If a single fistula be present in the perineum it is the custom of the writer to dissect this carefully down to the opening in the urethra. A metal sound is placed in the urethra and the patient raised into the lithotomy position. An incision is made round the external opening of the fistula and carried forwards and backwards for about an inch in the middle line (see Fig. 426). The opening of the fistula is dissected free from the skin and firmly grasped in a pair of rat-tooth forceps and the dissection carried down outside the fibrous wall of the fistula, using sharp-pointed scissors and a fine knife, and taking care not to cut into the lumen of the fistulous tube. Bleeding is controlled by pressure with pledgets of cotton-wool on holders. By keeping along the edge of

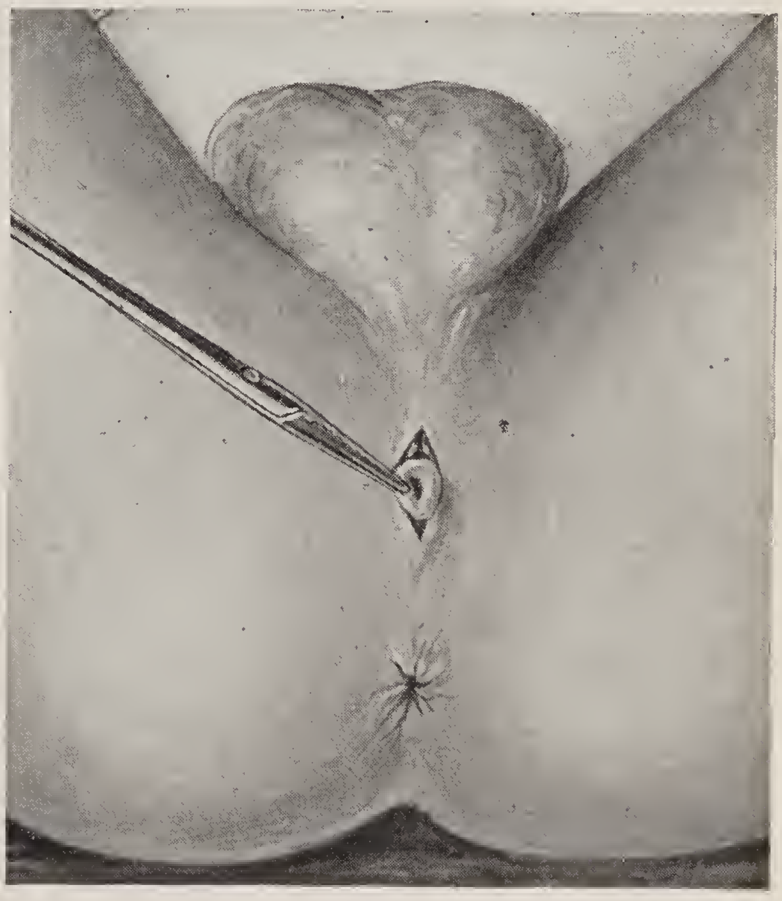

Fig. 426. Operation for Perineal Fistula. *First stage.* Incision round the opening of the fistula.

the fibrous and healthy tissues a fibrous tube is gradually isolated and pulled out until the metal sound can be felt lying in the urethra (see Fig. 427). When this is reached the fibrous wall of the fistula is cut across and removed. Any hard fibrous tissue remaining at the edge of the opening in the urethral wall is clipped away. Several catgut sutures are introduced through the wall of the urethra, avoiding the mucous membrane (see Fig. 428). These are tied and the perineal tissues are brought together over this with catgut sutures. A small drain is placed in the wound for two days and then removed.

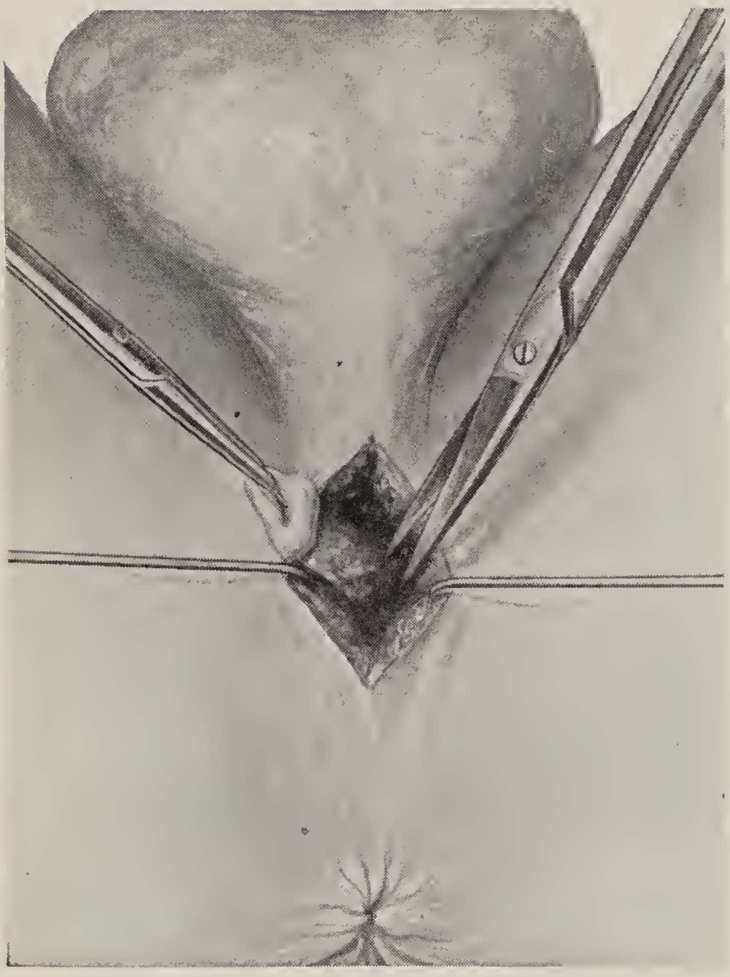

Fig. 427. Operation for Perineal Fistula. *Second stage.* Dissection of the fistula.

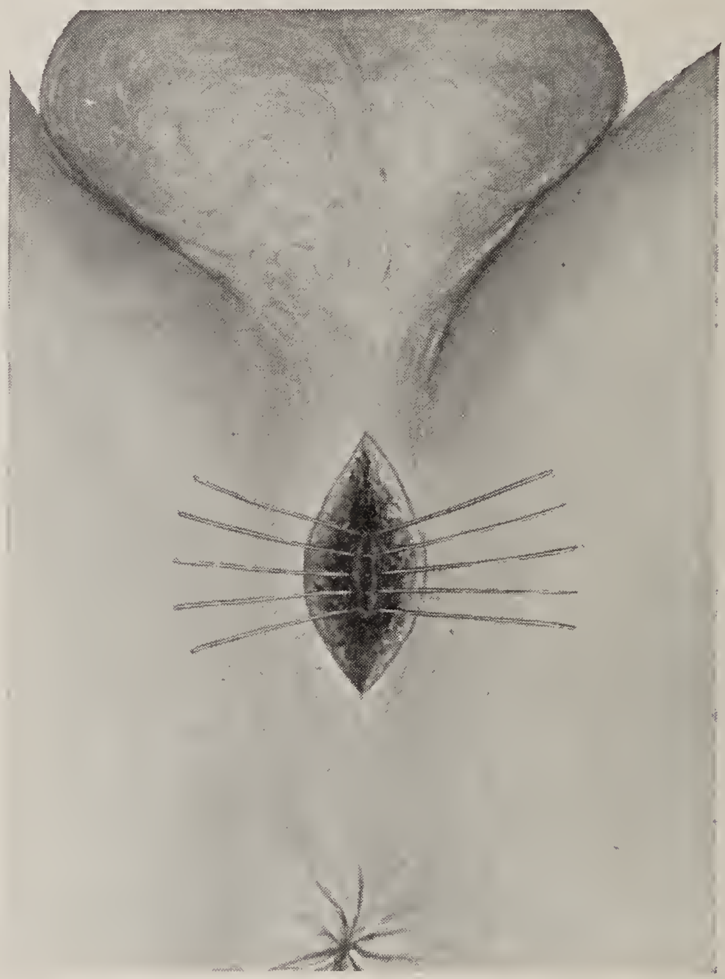

Fig. 428. Operation for Perineal Fistula. *Third stage.* The fistulous track has been removed and stitches placed in the edges of the urethral wound.

Where multiple fistulæ open upon the perineum and scrotum without much fibrous induration, excision of the tracks should be attempted. The operation entails careful and painstaking dissection. These multiple fistulæ have usually one opening into the urethra. Some of the windings and side tracks of the fistulous system may defy dissection, and these must be scraped and all thickened fibrous tissue clipped away.

FOR PERINEAL FISTULÆ WITH LARGE MASSES OF FIBROUS INDURATION

Operation. In cases where there are fistulæ of the perineum and scrotum with massive formation of cartilaginous-like fibrous tissue, it should be the object of the surgeon to remove the whole of the fibrous mass. Dissection in these cases is out of the question. It is the custom of the writer to commence by performing internal urethrotomy and introducing a curved staff into the bladder. The patient is then placed in the lithotomy position and a vertical incision made in the median line of the perineum, and this is deepened until the urethra is exposed and the groove can be felt in the staff. A knife is now run along the groove and opens about 1½ inches of the urethra. A gorget is slipped along the groove into the bladder, the staff withdrawn, and a large rubber perineal tube introduced. The gorget is removed, the tube closed with a pair of pressure-forceps, and the excision of the nodular masses of fibrous tissue now commenced. The median perineal incision is continued forwards on to the scrotum as far as the nodular thickening can be felt (see Fig. 429). In doing this one or several collections of pus buried in the fibrous mass are exposed. The tissue cuts like a turnip, and the cut surface is opaque greyish white. An occasional artery spouts and is temporarily picked up in forceps. From the anterior end of the incision another is commenced which passes out on one or other side, keeping at the edge, or very near it, of the indurated tissue, and sweeps round on to the perineum. This is deepened, inclining inwards, so as to remove a great wedge-shaped mass of fibrous tissue which is held aside in toothed forceps as the incision deepens. Spouting vessels are picked up and the finger passed over the cut surface in search of hard nodules. Wherever an outlying mass of fibrous tissue is seen or felt it is freely removed. With it probably goes a small buried pus sac, or the end of a fistulous side track. A similar procedure is now carried out on the

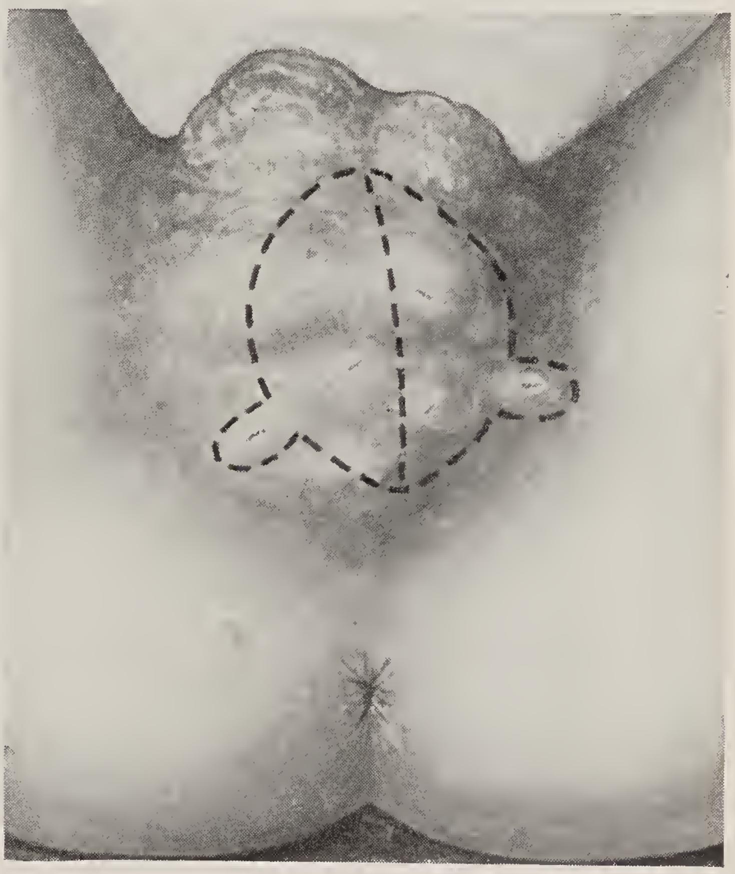

Fig. 429. Incision for the Removal of Fistulæ and Masses of Fibrous Tissue.

other side of the median line, commencing at the upper end of the incision and working downwards. In this way large fibrous masses, which cover an area the size of the palm of the hand and are several inches deep and thick, may be removed.

The next step is to repair as far as possible the defect left by this free removal of tissue. Commencing at the upper part of the wound, stout silkworm-gut sutures are introduced through the soft scrotal tissues from side to side and held up by an assistant. It is remarkable how little real loss of normal tissue there is, and how readily the skin comes together. When these sutures are tied, some part of the wound will probably not meet with the patient in the lithotomy position, but it will come together more easily when the thighs are adducted. Part of it will probably be left to granulate, and this is no great disadvantage. At the posterior part of the wound the skin again meets, and the tube should be secured in place by a suture passing through the skin on each side. The open part of the wound is lightly packed with gauze and a dressing applied and retained in position by a T-bandage.

After-treatment. The wound should be irrigated daily with a stream of biniodide solution. The bowels are kept confined for four days, and the tube is removed on the fourth day. At the end of a week or ten days a large steel sound is passed along the urethra and a gum-elastic catheter tied in for a week or more. Healing takes place in from three to four weeks, and the resulting scar is usually supple and healthy.

FOR THE REPAIR OF ACQUIRED URETHRAL DEFECTS

Autoplastic methods. The cases suitable for operation by this method are those in which some part of the urethral wall, usually the roof, remains intact, while a portion, sometimes very extensive, of the floor is wanting as a result of injury, extravasation, the removal of large calculi from the urethra, or other causes.

Two methods have been adopted, viz. (1) the undercutting and sliding together of skin and tissues on each side of the defect, and (2) the formation of definite skin flaps.

1. *The repair of the defect by undercutting and sliding.* An extensive defect of the floor of the urethra appears like a gutter with an opening at each end leading in the case of a perineal defect to the penile urethra in front, and the membranous urethra posteriorly. The skin and mucous membrane unite along each side (see Fig. 430).

A large bougie (No. 22 French) is passed along the penile urethra, appearing in the defect and disappearing into the membranous urethra.

The urethra in front and behind the defect is first exposed and isolated on its under and lateral surfaces for half an inch. This is done by making a median incision from the margin of the defect and dissecting on each side. An incision is now made through the skin along either side of the gutter and the skin and mucous membrane turned up over the bougie in two long flaps. At each end these lateral incisions pass into the wound made in dissecting out the urethra, and the end of this tube is now carefully pared. The lateral flaps are folded over the bougie and meet each other in the middle line, and at each end are in contact with the pared end of the urethra. A row of closely-set Lembert's sutures of fine catgut unite the flaps along the middle line and transversely with the urethra at either end.

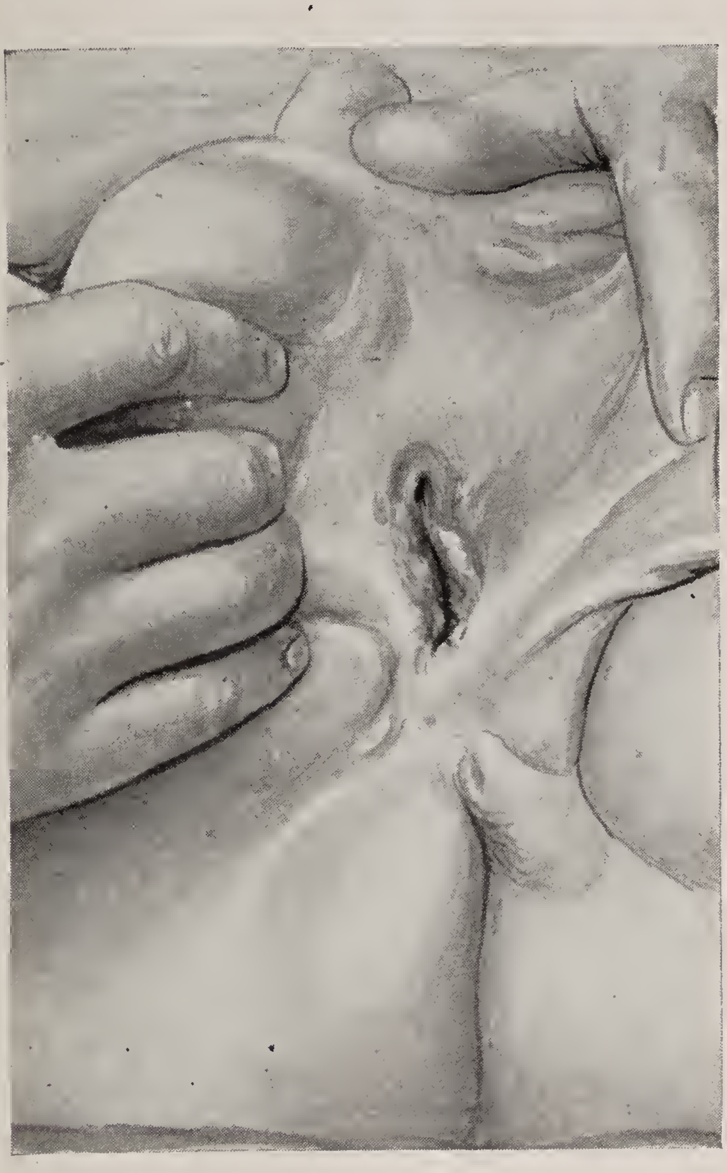

FIG. 430. EXTENSIVE DEFECT IN THE FLOOR OF THE BULBOUS URETHRA. (*Author's case.*)

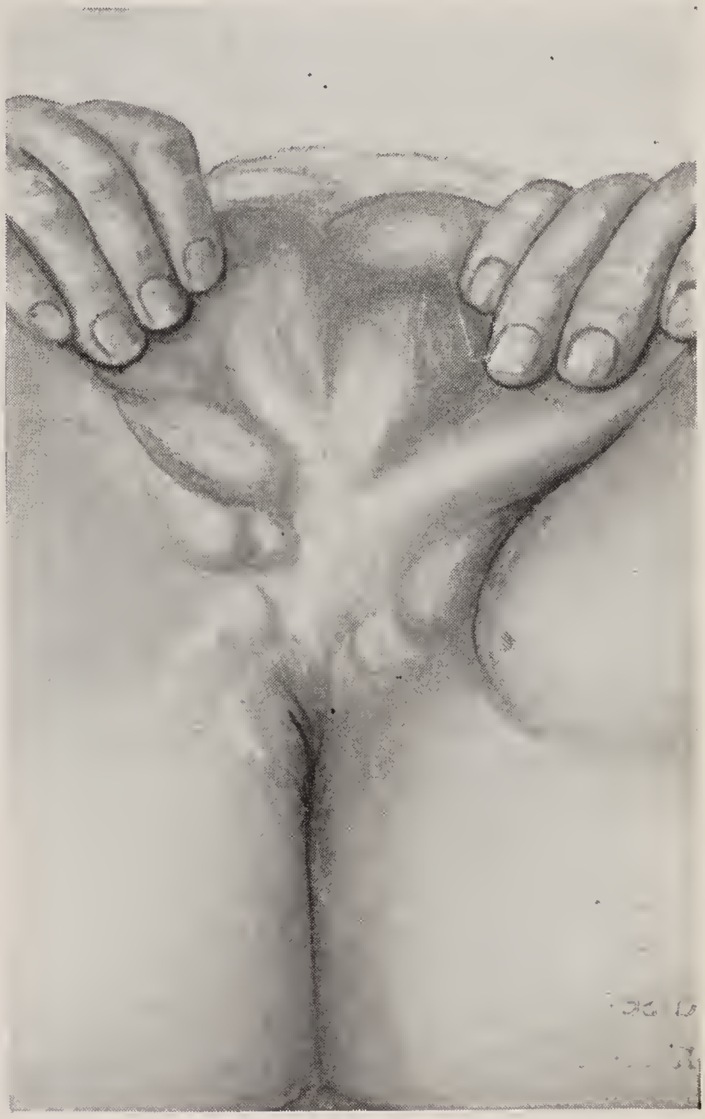

FIG. 431. RESULT OF OPERATION ON THE DEFECT IN THE BULBOUS URETHRA SHOWN IN FIG. 430. (*Author's case.*)

The next step is to unite the perineal tissues over this newly-formed urethra with a row of interrupted catgut sutures. This should be done without tension, and some undercutting may be necessary. The skin and subcutaneous tissues are now freed and united by silkworm-gut sutures. The instrument is removed from the urethra and siphon drainage of the bladder through the suprapubic wound established by means of a White's apparatus (see Fig. 317).

After-treatment. The urethra should be left undisturbed and suprapubic drainage continued for a fortnight. After that time the suprapubic tube may be removed and the wound allowed to heal (see Fig. 431).

2. *Repair of the defect by double superimposed flaps.* The cases suitable for this method are the same as those for which the preceding operation may be used, but it is absolutely necessary here that the skin should be supple and free from hair. This method was introduced by Guyon,[1] who cauterized the skin before performing the operation, so that no hairs remained. The procedure is as follows: On one side of the urethral gutter a quadrilateral flap is marked out with its base on the inner side, and this is dissected up so that when it is turned over its cutaneous surface is buried and forms the floor of the urethra at the part which is deficient. A second flap, with its base outwards, is marked out on the other lip of the defect, and this is dissected up and is made to slide inwards across the middle line so as to cover the raw under-surface of the first flap, and the borders of this flap are stitched to the edges of the raw surface from which the first flap was turned over.

Heteroplastic methods. The cases suitable for this method are similar to those for which the autoplastic methods are used. Where the urethra has been completely divided or a segment of it destroyed by disease and a broad gap intervenes between the ends, the heteroplastic methods are especially indicated.

1. For the purpose of closing the gap portions of tissue from other parts of the patient's body have been used. Keyes,[2] von Frisch,[3] Leprévost,[4] and Mensel[5] have transplanted the inner surface of the prepuce into the urethral defect. Keyes cleansed the inner surface of the prepuce and packed it with antiseptic gauze. He then excised a stricture of the urethra and removed a portion of the inner surface of the foreskin 1½ inches by 2 inches in extent, and placed it in warm boric lotion. When the bleeding from the urethra had ceased, he stitched the portion of prepuce in position in the roof of the gap left by the removal of the stricture.

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[1] Quoted by Albarran, *Médecine opèratoire des voies uriñaires,* 1909.

[2] *Journ. of Cutan. and Genito-urinary Diseases,* 1892, p. 401.

[3] *Internat. klin. Rundschau,* 1891, Nos. 26, 27.

[4] *Bull. et Mém. Soc. de Chir.,* Paris, 1890.

[5] *Berl. klin. Wochenschr.,* 1888.

Albert[1] and Dittel[2] use strips of mucous membrane taken from the lower lip to close urethral defects. Lapiejko[3] operated in this manner on three cases, in one of which the defect of the urethra measured 7 centimetres. He stitched the transplanted membrane to the urethra in front and behind and laterally to the soft tissues of the perineum.

2. Portions of mucous membrane taken from other human beings have also been used.

Wölfler[4] excised the callous parts of the urethra in a case of old stricture and allowed the gap to granulate. He then took strips of mucous membrane several centimetres long and 1 to 2 centimetres broad from the mucous membrane covering a prolapsed uterus, and laid these on the granulating surface of the urethral gap without fixing them with stitches. A catheter was tied in position and the grafts were left undisturbed for five or six days.

3. Mucous membrane taken from animals and birds has been transplanted into gaps in the human urethra.

Results. In the autoplastic and also in the heteroplastic methods of repair, complete restoration of the urethral canal has frequently been obtained. There is some danger of contraction at the points of union of the repaired with the intact portion of the canal. Sometimes several operations are necessary before the defect is finally closed. Wölfler performed heteroplastic operations after excision of urethral stricture in three cases, and in two of these a No. 20 French bougie passed easily, and the patients required no further treatment with instruments. One patient died from nephritis six months after the operation, and on examining the urethra it was impossible to say where the transplanted portion of the urethra joined the proper mucous membrane. In Keyes's case there was some contraction of the urethra a year later, but a No. 21 French bougie passed.

Lapiejko found that in one of his cases of transplantation of mucous membrane from the lip the patient was well two years afterwards.

Pringle[5] found that transplanted urethra obtained from bullocks continued to live and the urine passed through it. He found difficulty, however, in obtaining complete union at the anterior point of junction of the ox and human urethral mucous membrane, and in two cases this did not heal. In his third case a second operation was successful in closing the fistula.

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[1] *Deut. militärärztl. Zeitschr.*, 1890.

[2] *Wien. klin. Wochenschr.*, 1895, No. 20.

[3] *Annales des maladies des organes génito-urinaires*, 1894, p. 41.

[4] *Archiv f. klin. Chir.*, 1888.

[5] *Annals of Surgery*, Sept. 1904.

In one of his cases the transplanted urethra was excised on account of a persistent fistula, and replaced by another graft, and it was found that the tube, except at the fistulous opening, was healthy nineteen months after implantation. Another of his three cases died from renal abscess, and it was hardly possible to make out the line of union of the mucous membrane of the graft and that of the original urethra.

FOR THE REPAIR OF URETHRO-RECTAL FISTULA

Not uncommonly there are other complications, such as congenital stricture of the urethra and sometimes also calculi, found in the bulbous or prostatic portions of the canal. These complications must first be treated and then the operation for the cure of the fistula undertaken.

Operation. The bowel should be prepared by purging and enemata for some days before. If possible a steel bougie is passed along the urethra into the bladder. Suprapubic cystotomy is performed, and a drain inserted. With the patient in the lithotomy position a curved prerectal incision is made extending well out on to the ischial tuberosities, and this is deepened by dissection through the tissues of the perineum. The bulb is identified and freed posteriorly, and is then hooked upwards, and the wall of the fistulous communication can now be felt. If this be broad and short with a direct communication between the urethra and rectum, the dissection must be carried laterally round the rectum so as to get well beyond the fistula on either side. If possible the dissection should be carried upwards beyond the fistula so as to isolate it, but in doing this the fistula may be opened. If this happens the edges of the opening must be picked up in catch-forceps and the opening enlarged so that eventually the fistula is cut across between the rectum and the urethra. Dissection is now carried further so as to separate the rectum from the prostate and bring the fistula well into view. This dissection may be very difficult, for the septum between the rectum and urethra immediately above the fistula may be very thin. In this case the separation of the rectum should be commenced well out on each side and carried towards the middle line. The next step is to close the openings in the rectum and urethra. The edges of the rectal opening are first trimmed, and a series of interrupted catgut sutures introduced through the wall, avoiding the mucous membrane. This is reinforced by a row of Lembert's sutures. The opening in the urethra is now trimmed, and a silk-wove catheter replaces the bougie. The edges of the opening are brought together over this by interrupted catgut sutures, which do not penetrate the mucous membrane, and a second row placed over this. A rubber drainage tube is placed in the middle line, and the muscular tissues of the perineum united with catgut sutures. The skin wound is closed around the tube. The catheter in the urethra is removed, and a siphon apparatus attached to the suprapubic drain.

After-treatment. The perineal tube is removed on the fourth or fifth day, and the bowels are kept confined for at least a week. The suprapubic drainage is continued for fourteen days, and then the tube removed and the wound allowed to heal.

If the fistula has a narrow track of some extent the operation is easier. A director should, if possible, be passed along the fistula from the rectum and acts as a guide. A thread of silk may be passed round the fistulous tube and tied, and the tube cut across close to the rectum and the stump covered with Lembert's sutures. Dissection of the tube is now carried down to the urethral wall, which is similarly closed.

Albarran[1] advocates a median incision passing forwards from the centre of the transverse parietal incision, where the fistula communicates also with the perineum. He also recommends that if there is inflammation or abscess formation the perineum should first be freely incised and the fistula opened up and scraped, and if the fistula does not close after this a second operation should be carried out. Ziembicke[2] and Fuller[3] make an incision round the anus and carry it forwards in the middle line on the perineum and backwards over the coccyx. The extra-peritoneal portion of the rectum is isolated, the fistula cut across and closed, and then the rectum is twisted round so that the urethral and rectal openings of the fistula are no longer opposite each other. The rectum is fixed in this position.

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[1] *Loc. cit.*

[2] *Semaine méd.*, 1889, p. 379.

[3] *Journ of Cutan. and Genito-urinary Dis.*, April, 1897.

CHAPTER XXI

TUMORS OF THE BLADDER

By Benjamin Stockwell Barringer, M. D.

Historical. While tumors of the bladder were recognized for a great many years before the invention of the cystoscope, the modern conception of tumors of the bladder, their classification, diagnosis and treatment all date from the time when the cystoscope began to be used, thirty or more years ago. The most benign of bladder tumors, the pure papilloma, was the first to receive intelligent attention.

Nitze recognized the futility of operation upon such tumors, because the tumors were multiple, and often recurred again and again. So he devised an electric wire cautery, used through the operative cystoscope, with which he would snare off the papilloma, and so get rid of the growth without operation.

Nitze's first large series of cases was reported in 1896. His instrument was rather bulky, and a little difficult to use. I well remember seeing Nitze snare off a very large bladder papilloma in his office. The cystoscope was removed, and the patient passed the snared-off tumor. There was little bleeding, and after this — to me a major procedure — the patient got up and went home.

Beer, fourteen years later, first started to fulgurate papillomata by means of the high-frequency current. Any catheterizing cystoscope could be used the small fulgurating wire passed through the ureteral catheter tubes, and the tumor burned away in this manner. This was a much simpler method than that devised by Nitze, and came into very general use among urologists.

Both Beer and Nitze emphasized that their procedures should be used only on papillomata of the bladder, but urologists promptly began to fulgurate all kinds of bladder tumors, including infiltrating carcinomata. So that, while the cure of papillomata progressed, very many patients with carcinoma of the bladder were sacrificed to this thoroughly inadequate treatment.

Then slowly the technique of the surgical removal of these tumors began to develop. At the same time, radium came into prominence. The technique of the radium removal of carcinoma of the bladder was quite different from the surgical removal.

Surgery and radium were used in combination and in conjunction. Latterly various forms of cautery removal, diathermy and deep X-ray therapy have all been attempted. This brings us down to the present day, and to-day no one form of treatment is universally approved, with the exception of the fulguration of small bladder papillomata.

Etiology. Ninety per cent. of all bladder tumors occur on the bladder base, around the trigone. This is the area which is most frequently affected by inflammatory processes, the bacteria coming from the urethra or prostate (gonorrheal) or from the kidneys by way of the ureters.

This might suggest that irritation caused by infection may play a rôle in the causation of bladder tumors. We know that in analine dye workers excretion of the dye in the urine tends to tumor formation.

I have seen two cases at the Memorial Hospital in which a bladder stone rested directly upon a tumor, and it might be reasonable to suppose that the constant irritation caused by it was a factor in the production of the tumor. All of the foregoing, however, is speculation.

Pathology. It is not an over-difficult thing, from the pathologist's point of view, to classify bladder tumors, and to place them under their different heads, as tumors of epithelial, connective tissue, or muscular origin, with one class for the more unusual hydatid, dermoid, chondromous tumors, as follows:

1. *Epithelial tissue*
    - Papilloma
    - Papillary carcinoma
    - Infiltrating (non-papillary) carcinoma
    - Simple carcinomatous ulcer
    - Flat-squamous celled carcinoma
2. *Connective tissue group*
    - Fibroma
    - Myxoma
    - Sarcoma
3. *Muscle tissue group*
    - Myomata
4. *Heterotopic forms*
    - Chondroma, rhabdomyoma
    - Dermoid.

The difficulty that immediately confronts the clinician is that the cure of some bladder tumors does not imply the total removal of the tumor with its base, and subsequent pathological examination. Therefore, the physician has to diagnose many tumors from the cystoscopic appearance, and from small portions removed through the operative cystoscope. Further, all clinicians do not agree as to the heading under which a given tumor should be placed, still more confusing the matter.

The clinician is chiefly concerned with the first class, the tumors of *epithelial origin*, as they constitute the vast majority of bladder tumors, and it is his task to distinguish between the three chief groups of this class, the *papilloma*, the *papillary carcinoma*, and the *infiltrating* (*non-papillary*) *carcinoma*, as their life history, degree of malignancy and treatment are widely different.

By a *papilloma* is meant the fluffy red tumor, which is pedunculated, and often multiple. The growth as a rule is not solid, the cells are regularly arranged, there are no atypical cells, and there is no infiltration of the base. The *papillary carcinoma* is, as a rule, single, pedunculated, generally red in appearance, although there may be sloughy areas. The cells are atypical, both as to their arrangement, and as to the cells themselves.

The infiltrating carcinoma begins as a flat sloughy ulcer, sessile, and not pedunculated, with atypical cell growth and the tumor infiltrates the bladder wall.

Any of these may merge almost imperceptibly into the other. For instance, the papilloma may show in one portion of the tumor tissue which under the microscope is diagnosed as a pure papilloma, while other portions may be diagnosed as papillary carcinoma. Papillary carcinoma, early in its life history, may show no infiltration of the base, and later on, grow into the bladder wall, and infiltrate, and so take on the characteristics of an infiltrating carcinoma. Between the pure papilloma and the papillary carcinoma, many pathologists and clinicians have believed that there should be an intermediate type, which might be called malignant papilloma, and which might be described as looking like papilloma under the microscope, but having the clinical characteristics of carcinoma. It would seem that this title were better restricted to a clinical rather than a pathological variety, and the inclusion of it in the classification tends, I believe, toward confusion. If only portions of the tumor are removed for pathological diagnosis, the final burden for diagnosis lies with the clinician rather than with the pathologist.

Figures 432, 433 and 434 are examples of these three types of tumors.

Squamous celled carcinoma is a type which is infrequent. "Squamous celled epithelium is not found normally in the bladder. It may be present as the result of metaplastic change, due to some formation of chronic inflammation." In such an event, the carcinoma may arise from the metaplastic epithelium. A tendency to infiltrate the bladder wall is present, and ulceration is quite common. Fibro carcinoma, or scirrhus, may occur, but these tumors, as a rule, are primary in the prostate, as is also the case with adeno carcinoma.

Colloid carcinoma is quite rare. I have seen but one case in which I removed an enormous colloid carcinoma from the upper half of the bladder.

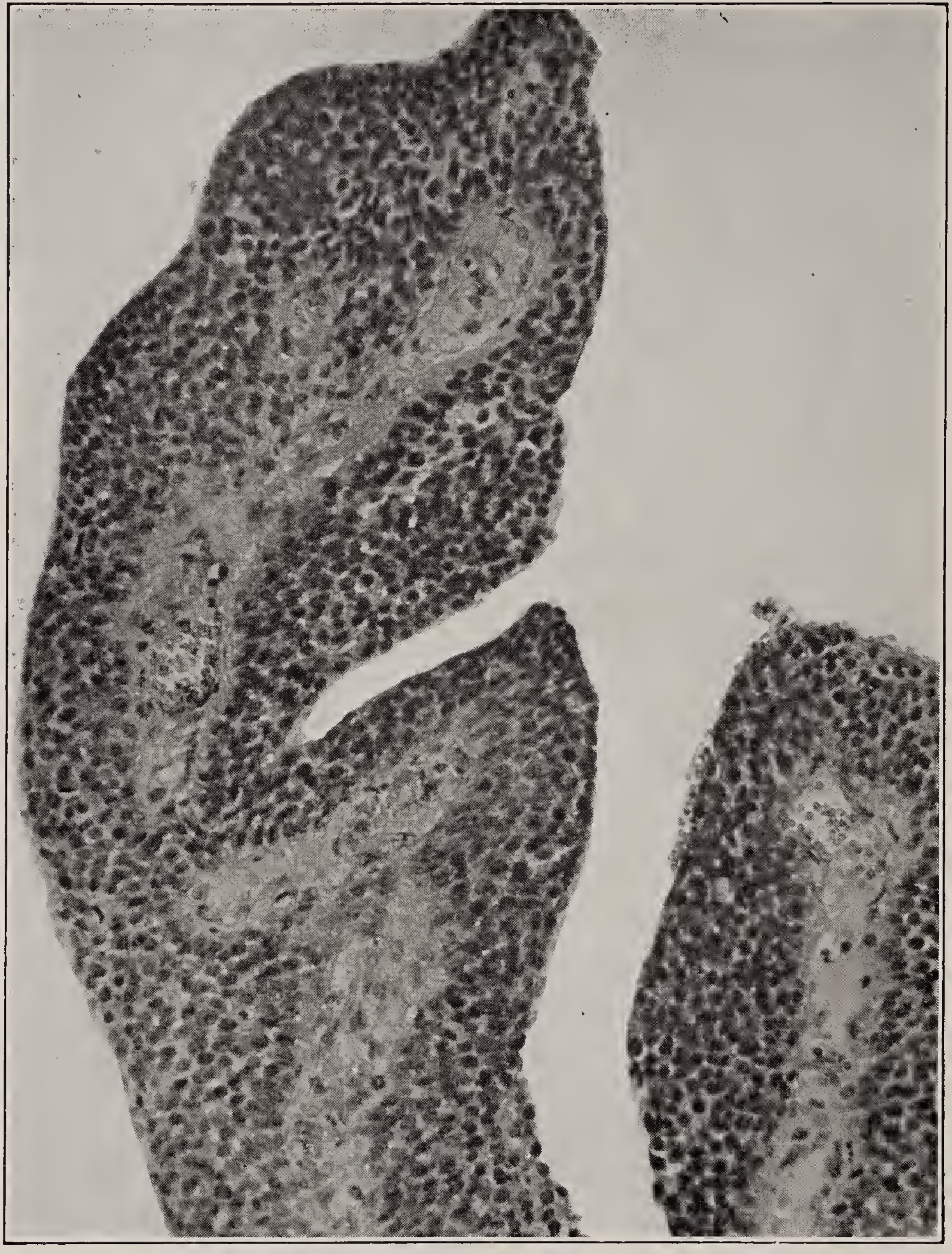

FIG. 432. Papilloma.

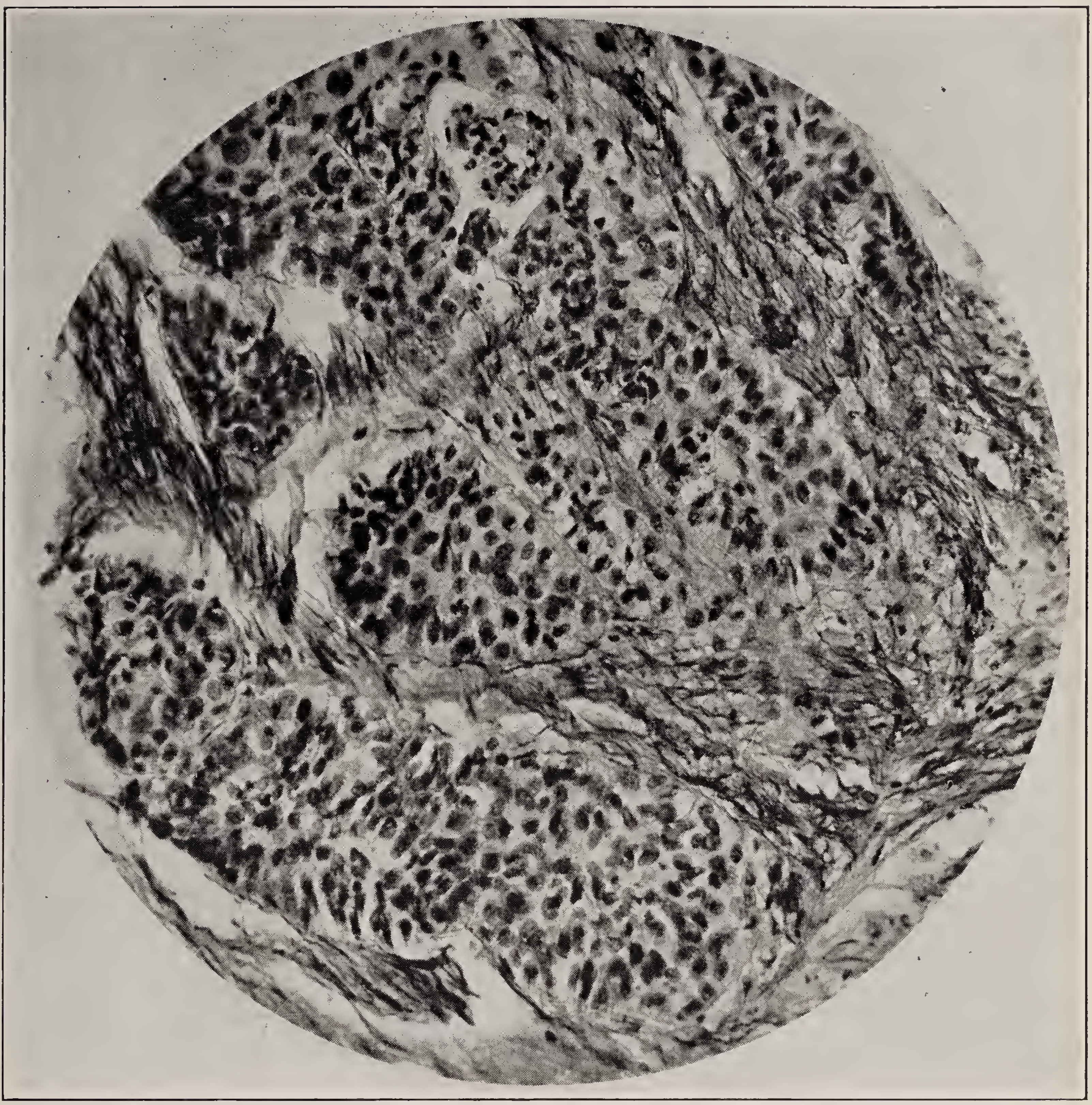

FIG. 433. Papillary Carcinoma.

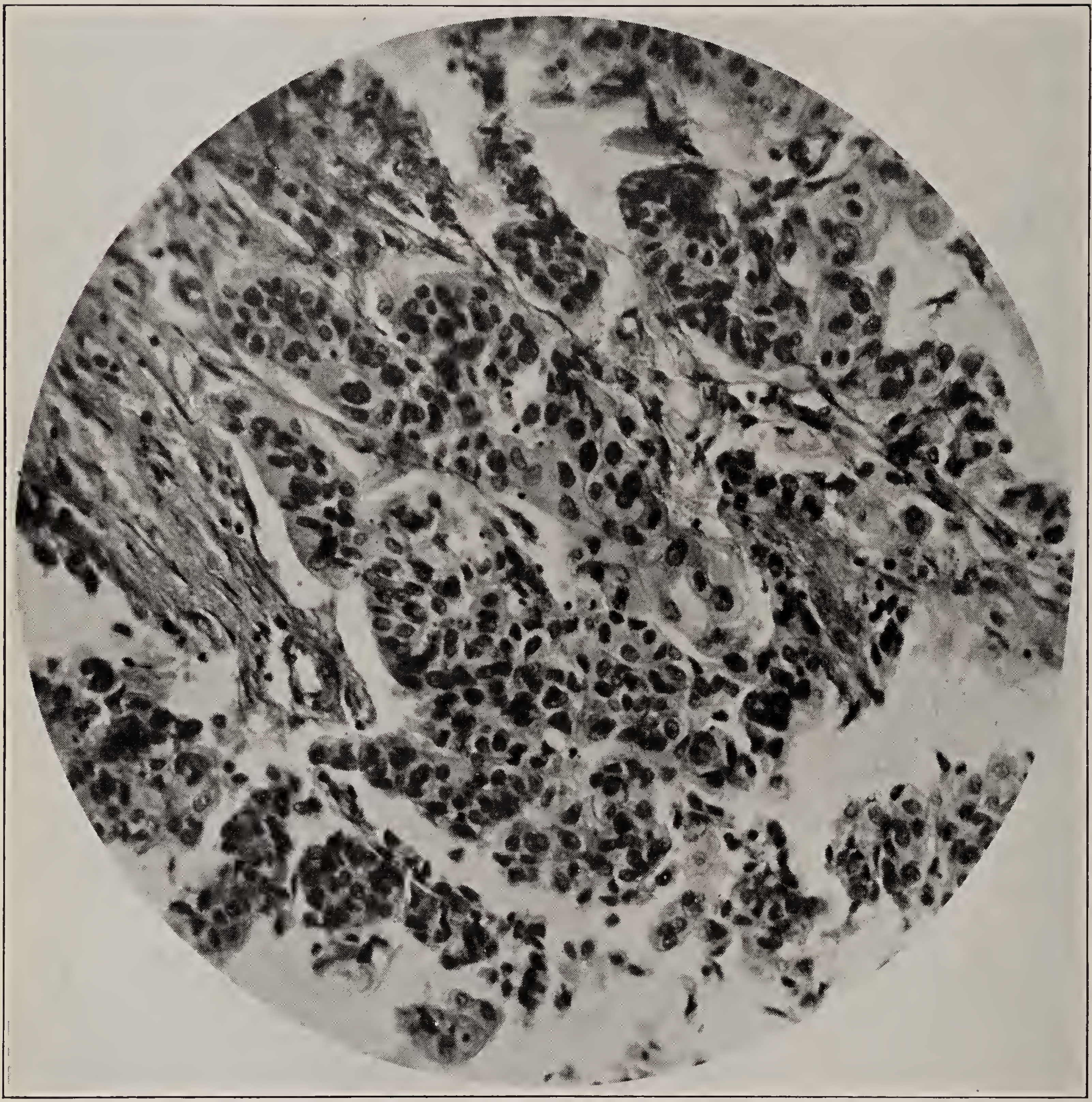

FIG. 434. Infiltrating Papillary Carcinoma.

Frequency of the various varieties of bladder tumors. Geraghty says that modern statistics prove conclusively that the papilloma is by far the most frequent tumor of the bladder. Yet in his series of 180 cases from the Johns Hopkins Hospital, 79 were diagnosed as papilloma. Albarran found 28 papillomata in a series of 98 tumors. Mandelbaum clarifies the situation when he says those writers who consider all papillomatous growths as benign, naturally call attention to the greater prevalence of such tumors, while others, who regarded this type as malignant, hold opposite views. He found 19 carcinomas in 29 cases, or 65 per cent. Zuckerkandel found 21 carcinoma in 32 cases of bladder tumors, or 60 per cent. so it would seem that the majority of bladder tumors are carcinomata.

Age first seen. In 73 patients with papillomata, 23 occurred between the ages of 41 and 50 (Geraghty) and but 13 over the age of 61. In 125 patients with carcinoma of the bladder seen at the Memorial Hospital, there were:

3 cases between the ages of 20 and 30 years.
16 “ “ “ “ “ 30 and 40 “
20 “ “ “ “ “ 40 and 50 “
37 “ “ “ “ “ 50 and 60 “
35 “ “ “ “ “ 60 and 70 “
14 “ “ “ “ “ 70 and 80 “

Therefore, the years of the greatest incidence of bladder carcinoma are between 50 and 70, at least a decade later than is the case in bladder papilloma.

Duration of symptoms. From our tables we find that most patients with carcinoma of the bladder have symptoms for a year or more before they seek treatment. This also holds with papilloma of the bladder.

Sex. Both papilloma and carcinoma of the bladder show a preponderance in the male. It is interesting that the older statistics showed cases evenly divided between the male and the female, but Mandelbaum's statistics show that only 9.8 per cent. occur in females.

Loss of weight and strength. In pure papilloma, this is a negligible factor. In 126 cases of advanced carcinoma, 39 cases showed a decided loss of weight and strength, but both of these, as symptoms of bladder carcinoma, generally appear late.

First and second symptoms. Hematuria is the one symptom which brings the patient to the physician, and is the first symptom in 70 cases out of 138 cases of carcinoma of the bladder. Some disturbance of urination, dysuria and frequency, is the second symptom of which the patient complains.

Location. In 15 cases of papillary carcinoma seen at the Memorial Hospital, 8 touched the bladder neck, 5 the trigone, 1 was on the lateral wall, 1 was on the base of the bladder. In papilloma and the infiltrating type of cancer, the location is about the same. In other words, most cases are in the vicinity of the trigone, the bladder neck, and the ureteral orifices. I personally have seen very few tumors of the apex of the bladder.

EXAMINATION

Cystoscopy. Examination by the cystoscope is the one means we have of determining both the presence of the tumor and its variety. Because of the bleeding which a tumor so often causes, it is not always easy to make a diagnosis. However, with a good cystoscope which allows free irrigation of the bladder, a clear field of vision should be obtained and the diagnosis is rarely in doubt. Blood clots may easily be mistaken for a real tumor process, as also may be the shaggy mucous membrane of a chronic cystitis. Stones covered with blood, and tumors with calcarious incrustations upon them may all confuse the picture. By means of the cystoscope, a small piece of the tumor may be obtained for pathological examination. This clinches the diagnosis. If possible, the piece ought to come from the deeper part of the tumor, or a portion of the tumor adjacent to the normal bladder wall. I have had the most difficulty in diagnosing the flat carcinomatous ulcer. When this tumor is small, it is very easy to confuse it with a simple ulcer. *A piece from the ulcer should always be removed through the cystoscope for pathological examination.* If a tumor is multiple, looks soft, is pink in color, floats in the bladder fluid like pink seaweed, then it is very probably papilloma. If it is single, peduncutated, looks firmer, somewhat of the consistency of a cauliflower, such a tumor is more apt to be a papillary carcinoma. If a portion of the tumor is distinctly sloughy, then it is surely carcinomatous. If the tumor is flat, ulcerating, sloughy, with what appears to be a thick, raised edge, it is a tumor of the infiltrating type. *i. e.*, a carcinoma.

Rectal or vaginal examination. The base of the tumor may be felt, or even the tumor itself, particularly if the other hand is placed suprapubically. Infiltration of the tumor beyond the bladder into the surrounding structures may be determined. The bladder should be empty for the examination.

Residual urine. Comparatively few cases of bladder tumor show residual urine. If it is present in any large amount (100 or 150 c.c.) it may mean that the tumor has invaded the prostate, or is primary there.

Kidney function. Forty per cent. of bladder carcinoma have reduced kidney function. This reduction is generally slight, but should be taken into consideration when any operative measures are contemplated.

Cystogram. The cystogram gives a better impression than cystoscopy of the size and extent of the tumor, and of the infiltration of the bladder wall. It is not always conclusive as to this last point. I have cystoscoped a patient whom I thought had a very extensive carcinoma, which infiltrated the bladder wall; the cystogram apparently confirmed this. At operation a very large pedunctulated tumor was found with a small pedicle, which finding wholly changed the prognosis.

To take the cystogram, the patient is placed upon his back, a catheter introduced into the bladder, the contents emptied. The bladder is blown up with air, and a stereoscopic radiograph taken.

Secondary urethral tumors. In a great many cases there are secondary deposits of the tumor in the urethra. This should be remembered, as with our eye on the main bladder tumor, we are apt to overlook growths in the urethra.

Bone metastases. When the tumor has extended beyond the bladder, such extension is observed in two ways. First, by means of rectal palpation, and second, by metastases in the bony skeleton as shown by the radiograph. Such metastases are osteoclastic, or bone destructive, while those in carcinoma of the prostate are osteoplastic, with new bone formation, the radiograph showing denser bone. Skeletal metastases are found in nine cases out of ten in the lumbar spine, pelvis or upper part of the femur. Once in a while the metastases skip the pelvis and lumbar spine, and first appear in the dorsal spine, but it is not practicable, unless there are special indications, to radiograph the whole skeleton in every case. I do not remember seeing a bladder carcinoma metastasize to the lungs, although I have seen sarcoma of the prostate do this. If the patient has bloody sputum, or any lung symptoms, a radiograph of the chest should be taken.

Metastases to the lymph nodes. Very rarely do any palpable metastases occur. If the urethra is invaded, we may have the secondary deposits in the inguinal lymph-nodes. I have seen this several times in women.

In twenty-seven cases of bladder tumors of varying extent, reported by Geraghty, in which a post mortem examination was made, there were demonstrable metastases in only five cases. Skin metastases have been reported, but are very rare.

Treatment. Not all urologists agree as to the various forms of treatment for different bladder tumors. All are agreed, however, on one point — that the tumor must be confined to the bladder, if any treatment is to be successful.

A general summary of the present-day views of the treatment of bladder tumors is as follows:

1. SMALL PAPILLOMATA

Fulguration through the cystoscope by the unipolar, or better, by bipolar methods, is the accepted treatment. Most papilloma can be easily destroyed by this method. If the tumor is resistent to fulguration, then the tumor is not a pure papilloma, but a papillary carcinoma. Geraghty first made the observation that if such tumors are exposed to radium, they react quite differently to fulguration.

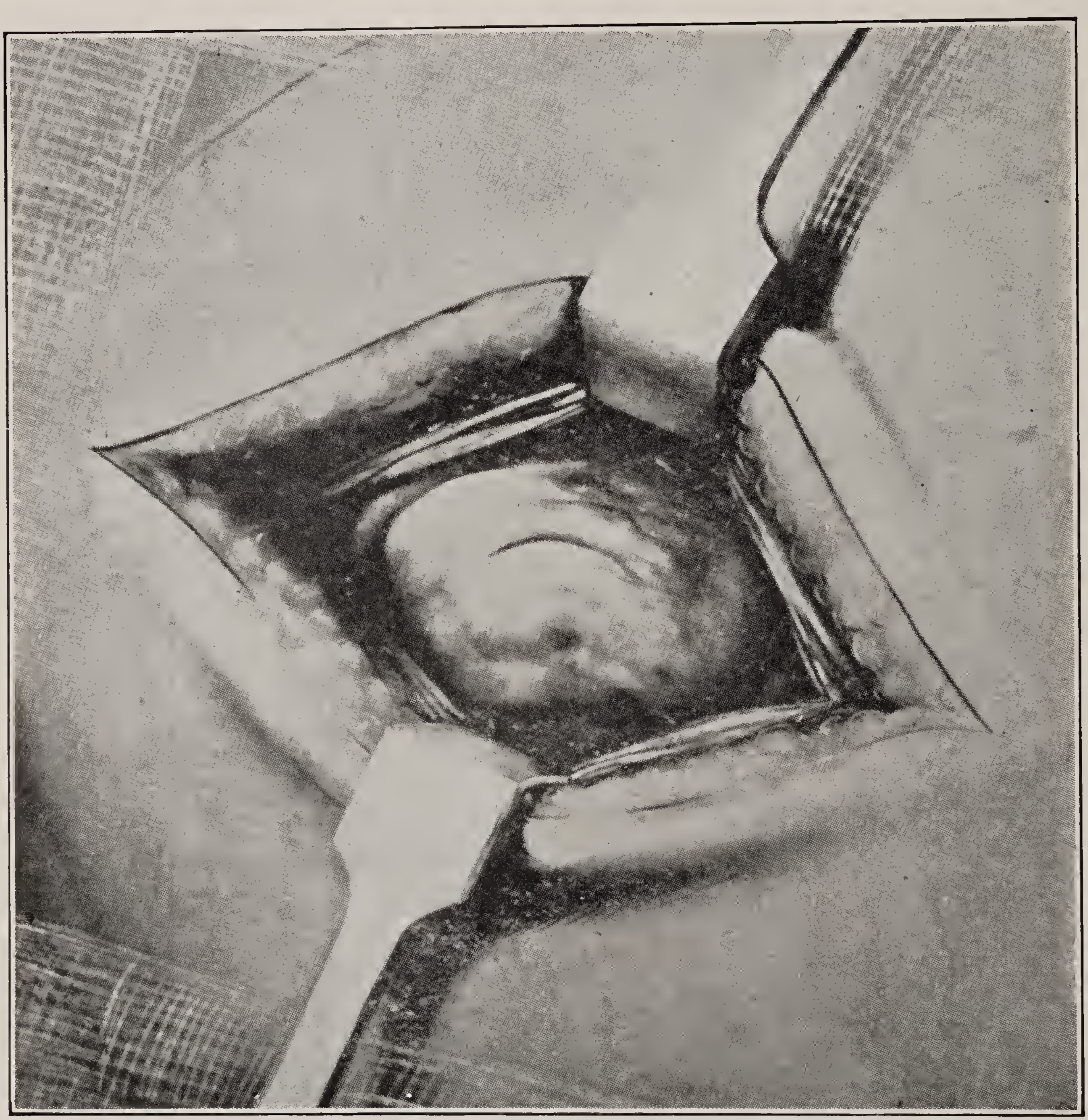

Fig. 435. Wide extraperitoneal suprapubic exposure of bladder in moderate Trendelenburg position after irrigation and emptying of organ. (Courtesy of Annals of Surgery)

2. LARGE EXTENSIVE PAPILLOMA

There is a difference of opinion as to the best method of treatment for this variety. When the bladder wall is filled with multiple implantations, and the bladder more or less filled by the growth, I prefer to do a suprapubic operation, open the bladder, and destroy the tumor by fulguration, or by the actual cautery. I believe that this should be followed by radium applications to the tumors, as only too often will the base of such tumors show malignant degeneration. On the other hand, it is difficult to apply radium directly to the bases of such tumors, because of their ex-

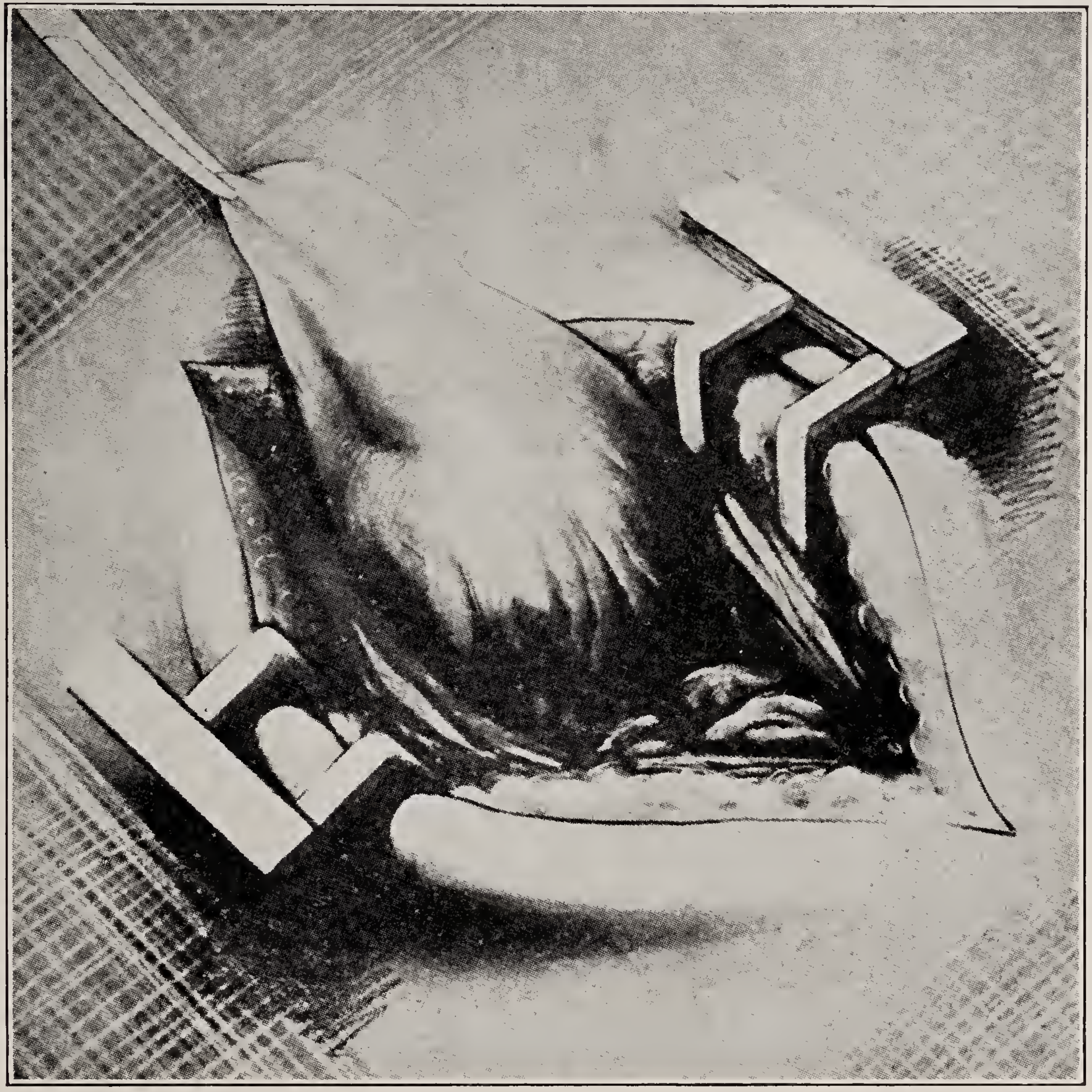

FIG. 436. Bladder completely freed by sponging off peritoneum and perivesical nonadherent fat. Posterior surface of bladder presenting as apex is drawn over pubes. (Courtesy of Annals of Surgery)

tent. It can be done fairly well by packing radium-bearing tubes up against the tumor bases at the time of operation, and pulling the radium tubes out when the appropriate dosage has been obtained.

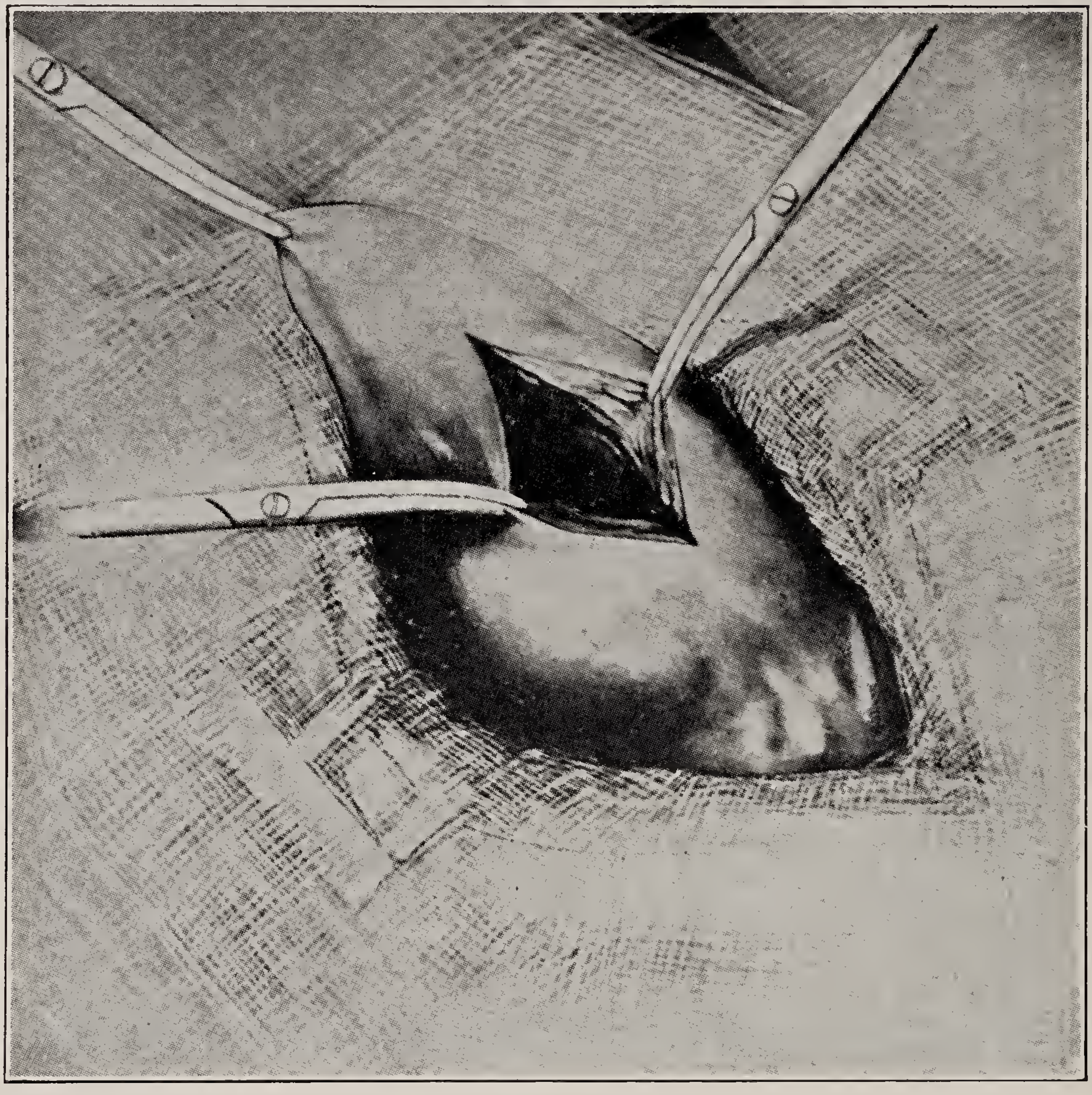

Fig. 437. Heavy gauze pads surround the bladder and carefully protect all parts of the wound. Incision through posterior wall of bladder. Edges of incision seized with curved blunt forceps. (Carmalt type.) (Courtesy of Annals of Surgery)

3. SMALL PAPILLARY CARCINOMA

Here again urologists differ radically. Most believe that direct surgical removal is the method of choice if the tumor is easily accessible on the lateral wall or vault of the bladder. If the tumor is at the internal urethral orifice, or firmly attached to the trigone, then it is generally conceded that direct surgical removal is not the method of election.

Surgical removal. Beer has developed a surgical technique for the removal of the above growths, which is shown in the accompanying plates. (Figs. 435, 436, 437, 438 and 439.) Because of his fear that tumor implants may occur in the operative wound, he cauterizes the growth with the actual cautery after opening the bladder, and then with the cautery removes the tumor with the adjacent bladder wall wide of the tumor growth. There should be a minimum of rubbing and sponging of the tumor; the raw surface around the tumor should be carefully covered with gauze packing, and Beer uses alcohol in the bladder and wound for five minutes, with which he hopes to " coagulate any potential cell implants " that have broken away during the various manipulations. If the ureter is involved, that is cut off and reimplanted.

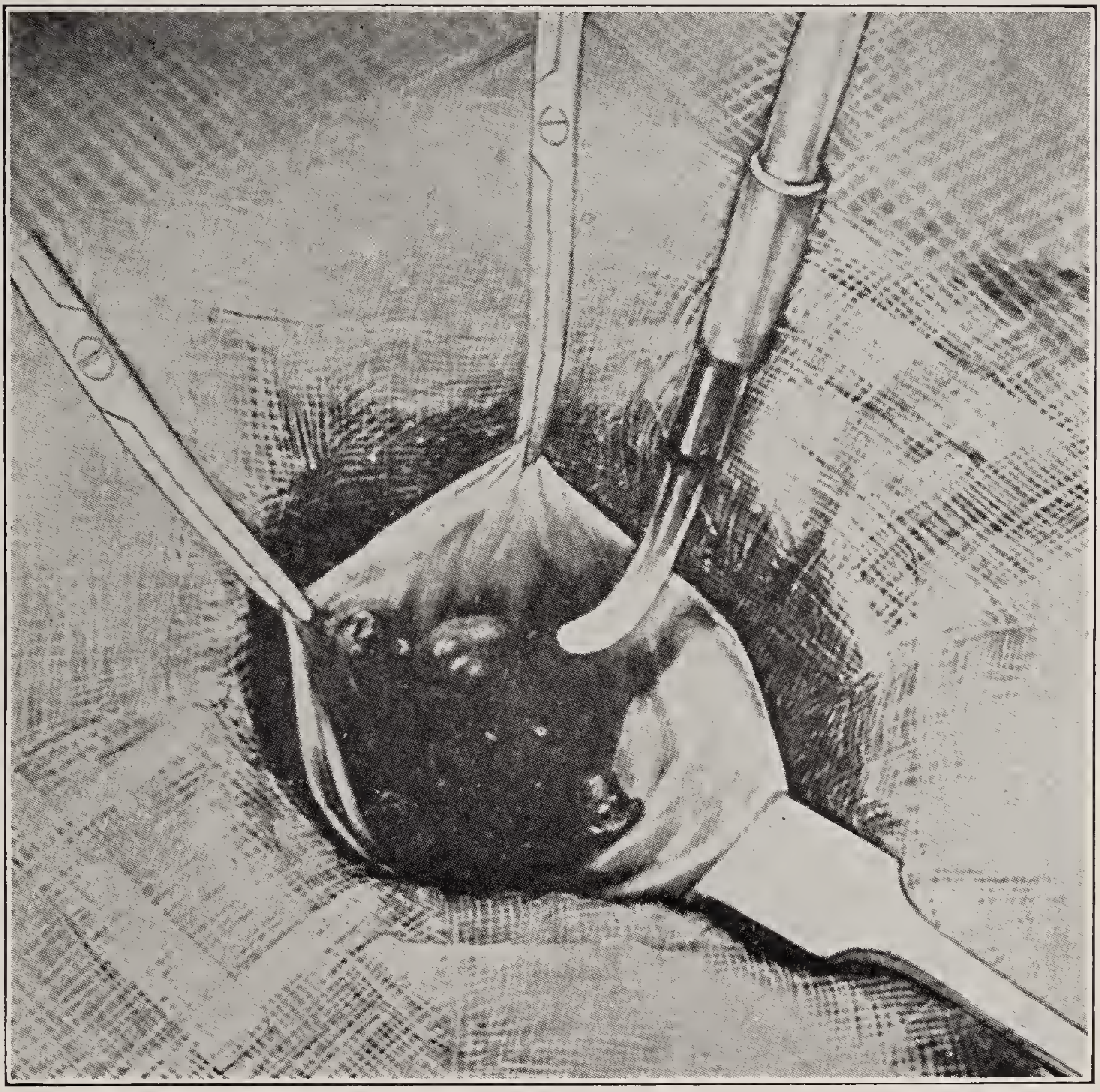

FIG. 438. The incision in the bladder has been gradually enlarged exposing numerous papillary tumors. With the cautery they are burnt to a crisp and their bases destroyed. (See text for resections and ureter implantations.) (Courtesy of Annals of Surgery)

If these small papillary carcinoma are so situated that they can be well seen through the cystoscope, I prefer to use radium for their treatment, and I believe such growths can be controlled and removed from the bladder in most cases without operation by the following method.

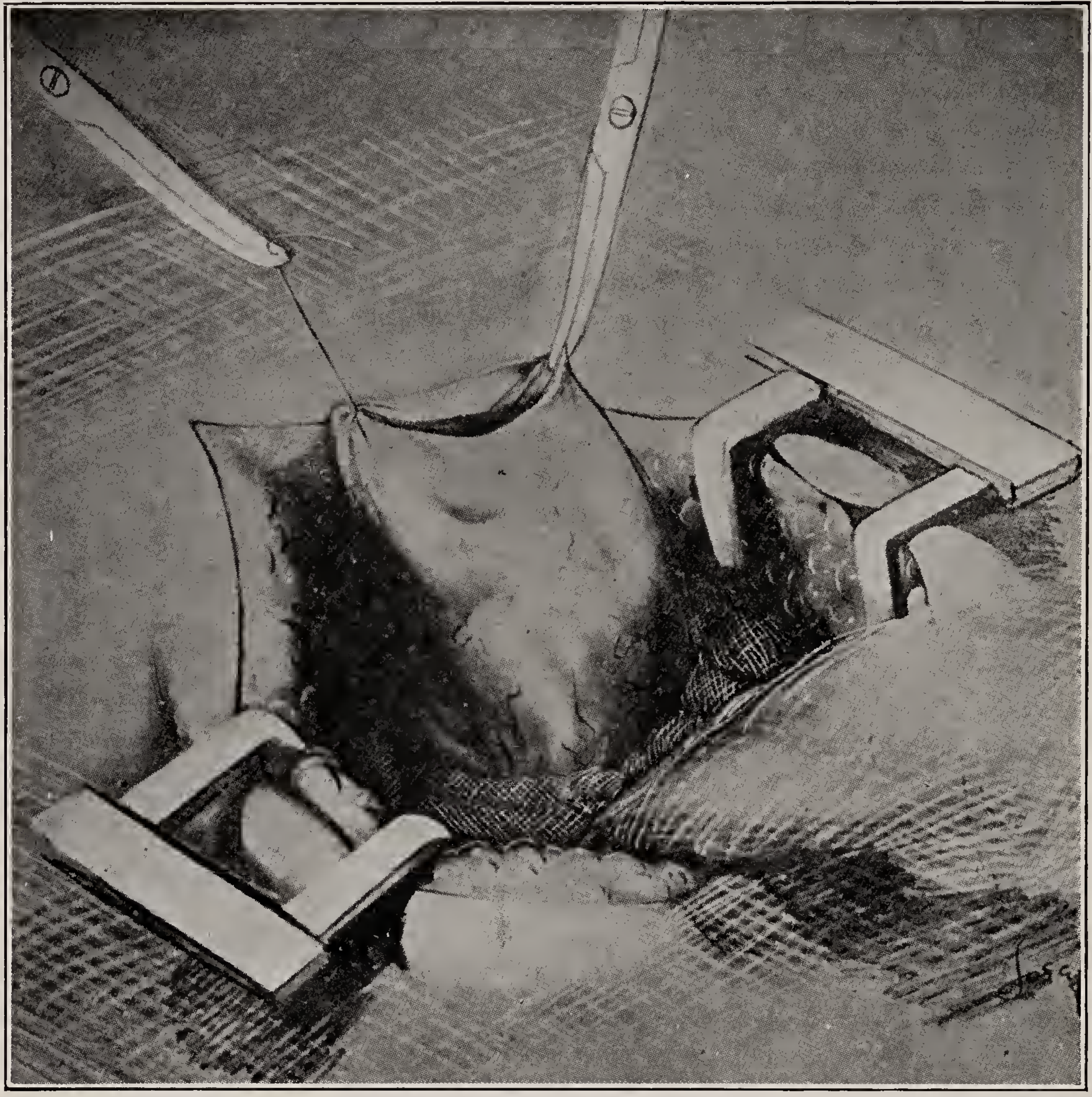

FIG. 439. After removal of soiled gauze and of the alcohol, the charred incision in bladder is inverted with two layers of sutures leaving adequate opening for tube drainage. (Courtesy of Annals of Surgery)

Intravesical removal of small papillary carcinoma by radium. By means of a flexible spring holder used through the sheath of the Brown Buerger operative cystoscope, 200 or 300 millicuries of unscreened radium may be held up against the tumor for the period of half an hour, while the tumor is being observed through the cystoscope. This may be repeated every two weeks, or less often if the tumor is disappearing satisfactorily. If the tumor looks solid or hard, or has a base which looks indurated, then it may be treated by thrusting into its base or indurated part a cystoscopic needle containing small bare tubes (seeds) of radium. For this purpose bare tubes of 0.5 millecuries to 1 millecuries of radium to a square centimeter of tumor are used, and left in place. The action here is local and caustic. I have lately used gold screened seeds of the strength of 2 millecuries, and these give much less irritation than the glass seeds.

4. SMALL INFILTRATING CARCINOMA

The same views and the same differences of opinion exist in the treatment of these tumors as in small papillary carcinoma.

5. LARGE PAPILLARY CARCINOMA, AND LARGE INFILTRATING CARCINOMA

The *operative removal* of these is difficult, and implies extensive partial resection of the bladder or total cystectomy with implantation of the ureters in the skin or intestinal tract. The latter operation, because of its high mortality, because of the difficulty of proper disposal of the ureters, has never become popular, and has never been widely done.[1]

Radium. I prefer to use radium through the suprapubic wound, and to implant it in these tumors in the following manner:

Low spinal, combined with local anesthesia along the line of incision is used. The bladder is prepared previous to operation by washing it out with a 1:4000 acraflavine solution. The sides of the wound are screened with gauze. The bladder is not mobilized as is done when a tumor is surgically removed. The bladder is gently palpated so the incision may not go through tumor tissue. Between clamps the bladder is opened by a three- or four-inch incision made longitudinally. The exposed tumor is sponged as little as possible to prevent bleeding and spreading of tumor cells. Any protruding portions of the tumor are snared off, using a simple wire snare. If the tumor is flat and not papillary in type, none of it is removed. My reason for snaring off the papillary part of the tumor is to expose and treat the base more readily. Indurated parts of the tumor are implanted with bare radium tubes (0.5 mc) by means of a needle, using two of these tubes to the square centimeter, or better and more lately, gold tubes of 2 mc, using 1 to $1\frac{1}{2}$ sq. cm. These bare tubes are not put into the normal mucous membrane, but within a quarter of a centimeter of the edge of the tumor. The bladder is drained for several days. A case operated upon in this manner is here reported to show what can be done in an inoperable tumor (aside from total cystectomy).

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[1] (*a*) If the ureters are implanted in the skin, a urinal has to be devised to catch the urine.

(*b*) If they are implanted in the intestines, there is grave danger of ascending renal infection, destruction of the kidneys, and death.

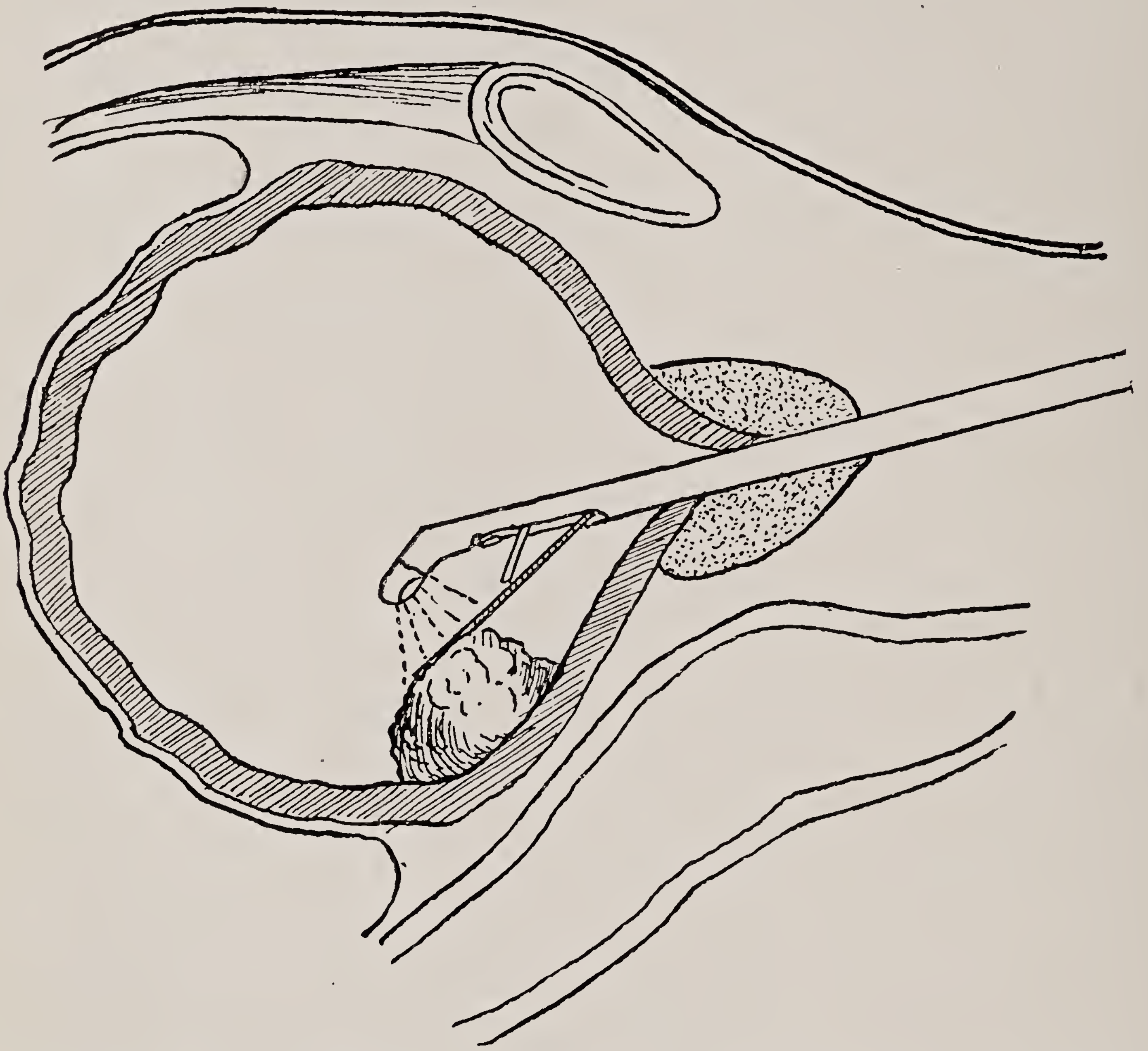

Fig. 440. Surface application of radium emanations to growth under vision by means of special applicator in cystoscope. (Courtesy of Annals of Surgery)

W. H. M., first seen Dec. 19, 1920, age 50, with a history of frequent and burning urination and hematuria, lasting for three months.

Cystoscopic examination showed a sessile, sloughy tumor of the anterior bladder wall, beginning at the internal urethral orifice, and extending upward. A cystotomy was done, and a flat carcinoma, 3 × 4 cm., was seen. It touched the internal urethral orifice. It was implanted with radium by the above method. The pathological examination by Ewing of a removed piece showed infiltrating squamous carcinoma. Subsequent to this, the patient had a good deal of tenesmus and burning, and calcarious encrustations occurred upon the slough.

On Dec. 21, 1922, his bladder was opened again, and a stone removed. At that time, no tumor was present. He is perfectly well to date, January, 1926, and is doing a full day's work.

Results. At the present time it is very difficult to compare results of fulguration, surgery, radium, and other forms of treatment, because of the wide variations in the classification of bladder tumors. A just summary of the various methods would appear to be as follows:

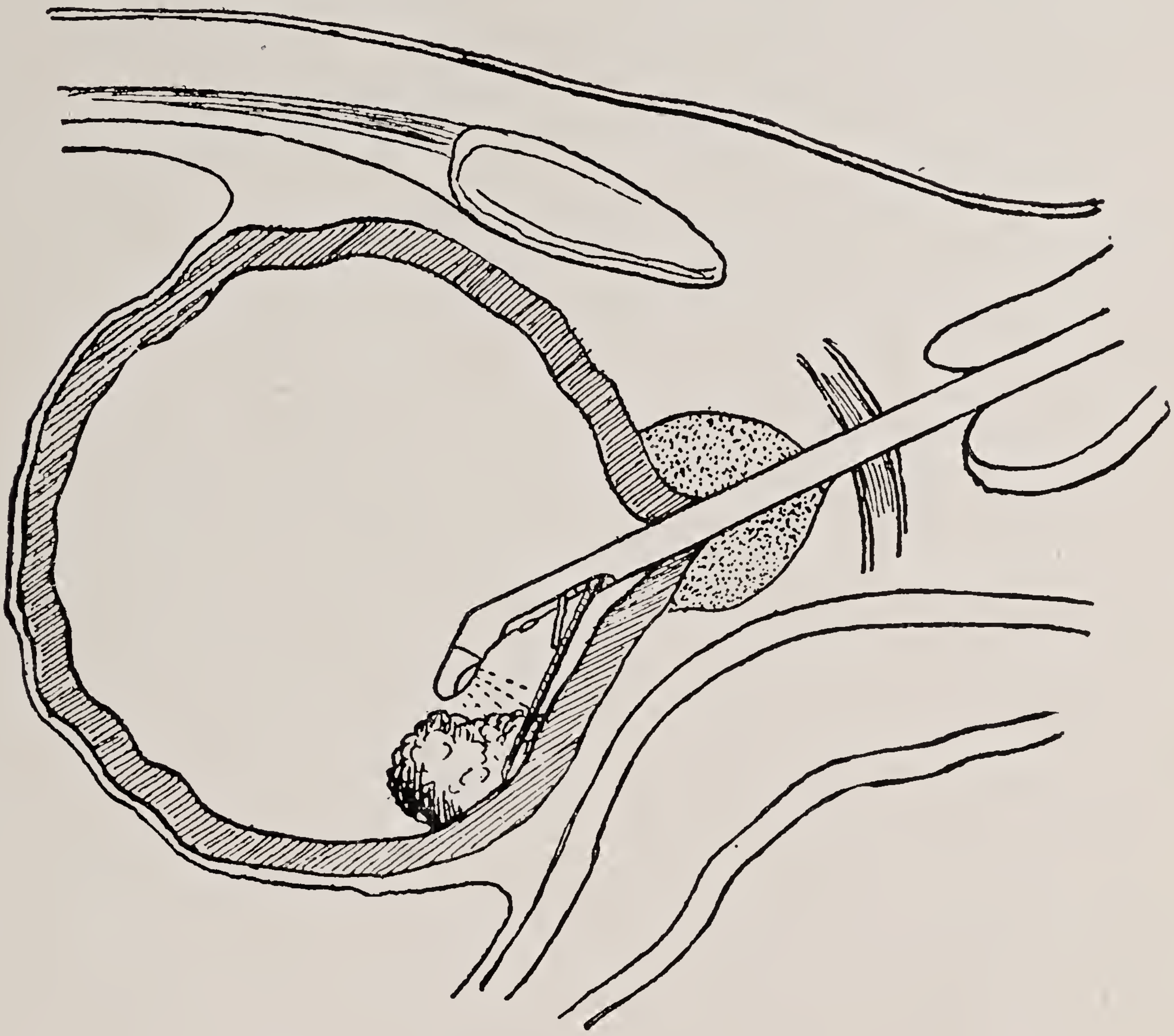

FIG. 441. Method of burying radium emanation tubes in growth by means of special introducer and the cystoscope. (Courtesy of Annals of Surgery)

1. Fulgurate the papillomata through the cystoscope, or if the growth is extensive, through the open bladder, with the expectation of a good result. The smaller the papilloma, the better the result. If the growth is once destroyed, persistent cystoscopies every few months are necessary. This holds for all bladder tumors.

2. Both radium and surgery can cope with *small papillary carcinoma*, and not so well with *small infiltrating carcinoma*. If surgical removal is used in these cases, there is a higher mortality than when radium is used through the cystoscope, by cystoscopy alone. When radium alone is used,

a slough of the bladder wall occurs and irritation in the bladder may persist for some time. If the tumor is near the bladder neck or trigone, the pain caused by the radiation may be very considerable. Yet, in this position, operation is quite impotent and undesirable.

3. *Large papillary carcinoma* and *large infiltrating carcinoma.* According to our present methods, neither surgery nor radium can hope to control many of these, and it is in this class that the greatest advances may be expected to take place.

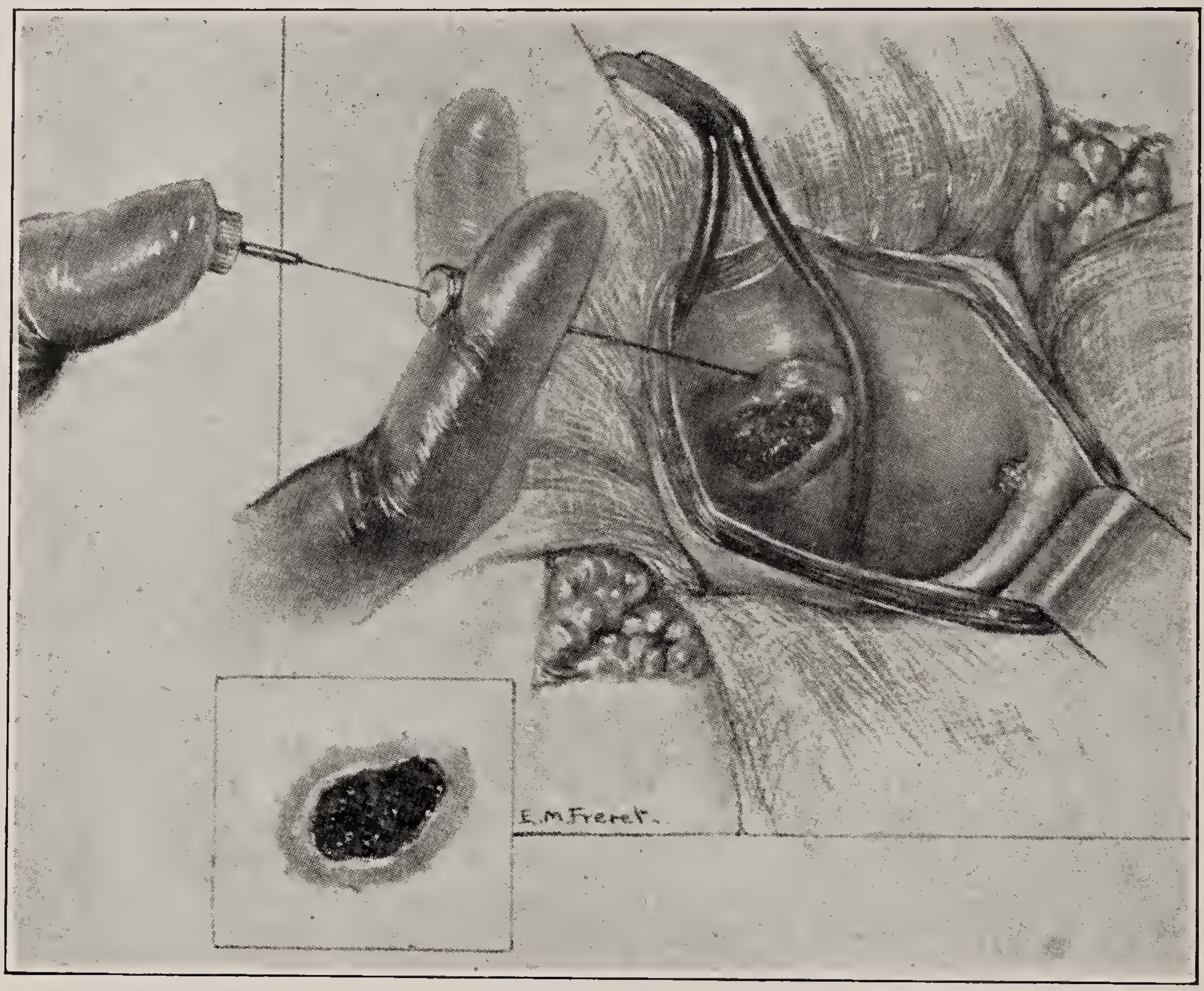

Fig. 442. Burying radium emanation tubes under direct vision after exposure of carcinoma by suprapubic cystotomy. (Courtesy of Annals of Surgery)

Deep X-ray therapy. There have been a few cases reported in which deep X-ray therapy has removed tumors from the bladder. My results have been very indifferent, and I find that neither hemorrhage nor other symptoms is often controlled by deep X-ray therapy.

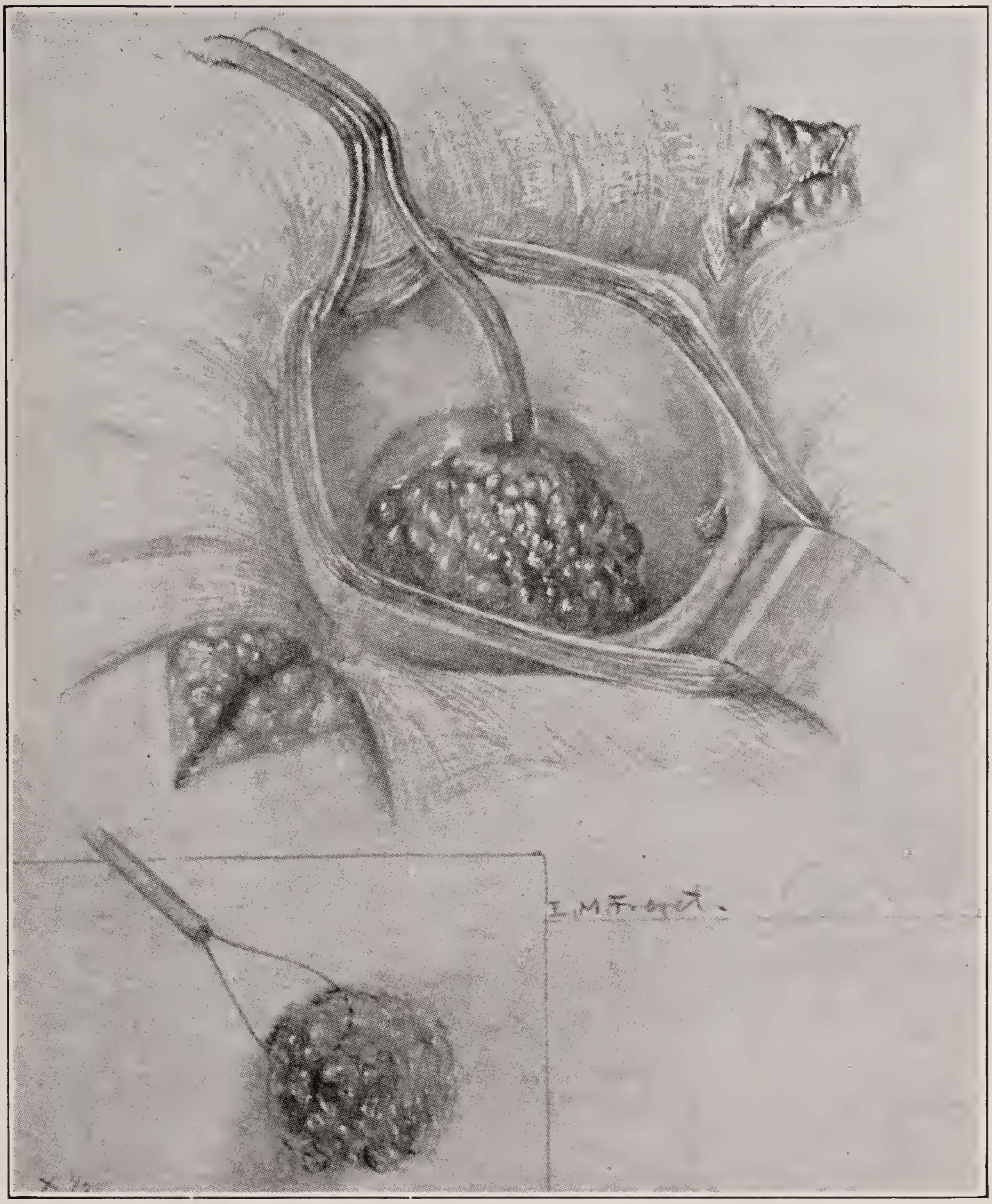

FIG. 443. Use of special retractor in exposing clearly the carcinoma, especially its base. Snaring off pedunculated growth preparatory to burying radium emanation tubes in its bore. (Courtesy of Annals of Surgery)

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THE DISEASES OF THE MALE URETHRA

BY

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ANATOMY OF THE MALE URETHRA

General considerations. The urethra is the mucous-lined channel leading from the bladder and forming its outlet. Unfortunately for males, it is in them a rather complex structure. The interior of the urethra is not smooth but has many openings which lead into the glands of Littré, Cowper's glands, the prostate gland, and the seminal vesicles. These ducts and their connected organs provide protected sites for infections which, at times, add greatly to the difficulty of curing urethral inflammations.

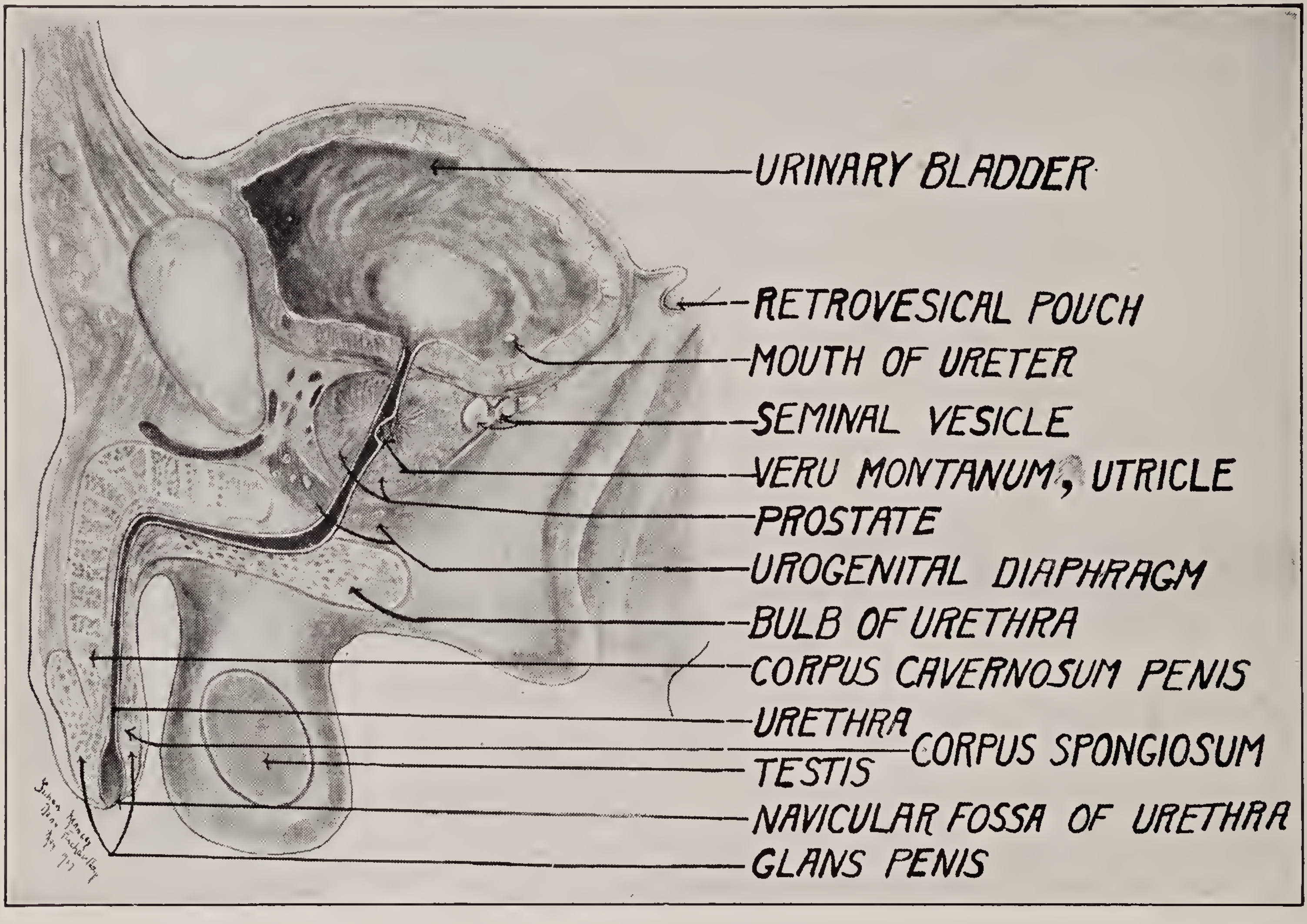

FIG. 1. Sagittal section of urethra and lower genito-urinary tract.

Persisting infection or abscesses in the glands of Littré often result in localized urethral or peri-urethral inflammation which is likely to terminate in urethral strictures.

In its anatomy, predisposing causes of two of the main affections of the urethra are seen: namely, persistent infections and obstructions.

The urethral follicles and adnexa are of prime importance in the management of urethral infections, and the patency of the urethra is of equal importance in dealing with the non-inflammatory urinary and sexual affections. Certain types of pain, itching, and the so-called " nervousness " of many patients, who have few " leading " symptoms and who go hopelessly from doctor to doctor to be treated for ill-defined conditions, often can be cured by attention to urethral obstructions and the hyperemia or hyperesthesia of the mucosa back of the stricture or of the more sensitive verumontanum.

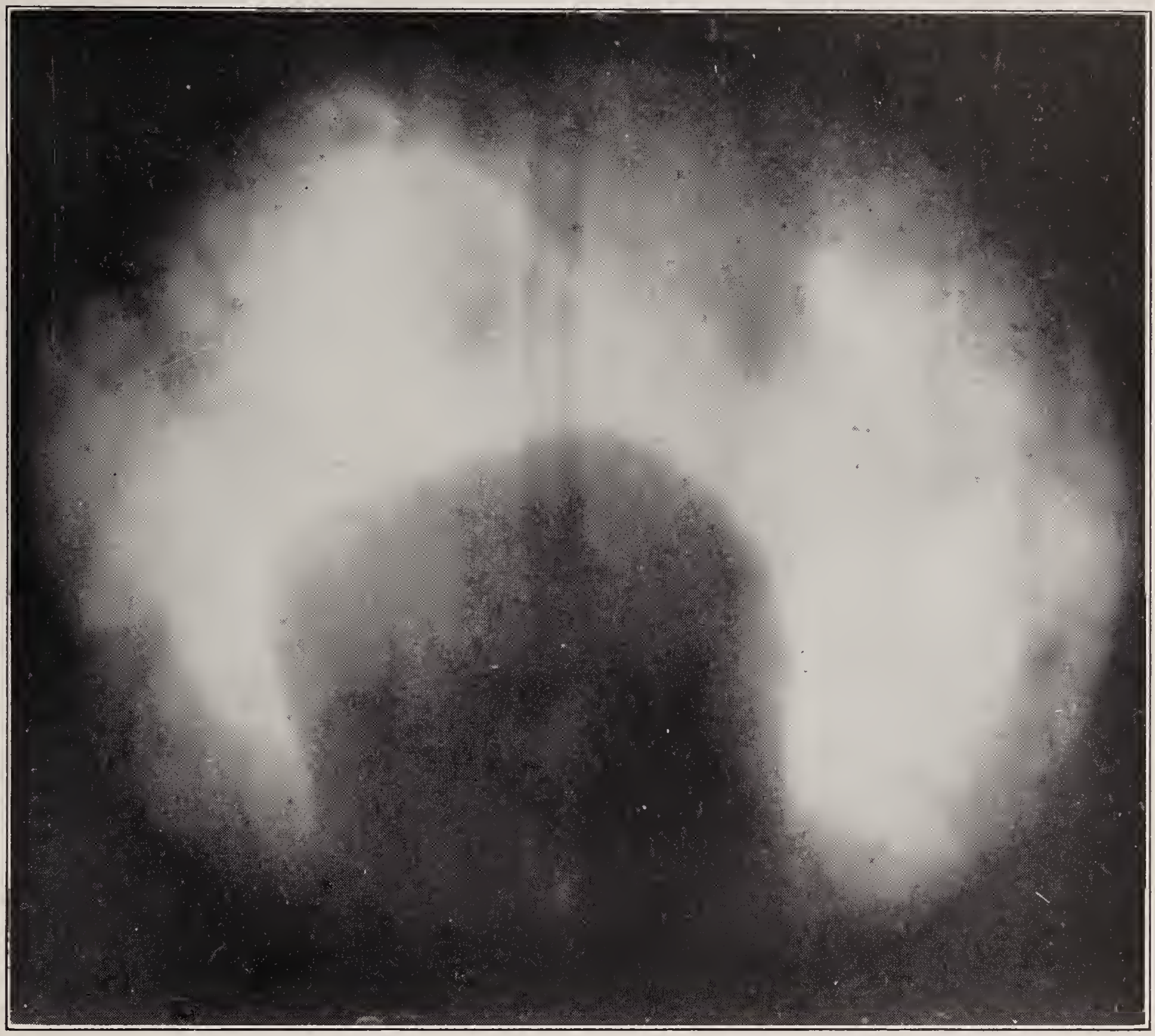

FIG. 2. Air cystogram of the bladder showing urethra lengthened by prostatic hypertrophy.

Higher immunity is required for the eradication of inflammatory conditions when the organisms are in a protected focus than when they are not thus protected; accordingly, a cure is hastened if, by controlling the inflammation in the urethra, the patient's well-being is promoted and his immunity increased, or if the focus is attacked directly.

The physician may hasten the cure by remembering the likely anatomic foci which protect the organisms and by applying appropriate measures. Emphasis upon the connecting urethral adnexa is not intended to convey the idea that meddlesome investigations of acute conditions, which might otherwise respond to mild measures appropriately applied over the usual period of time, are advisable. The foregoing remarks are made, however, to emphasize the importance of making reasonable examinations, at least visually and by palpation, and to urge that anatomic handicaps be not allowed to lead to early and overenthusiastic investigations which might bring about complications or lower the immunity upon which the cure so largely depends.

The anatomy of the urethra also shows clearly the futility, as well as the folly, of employing concentrated or irritating germicides which at best can never reach all of the infected organisms when the inflammation is well established. For chronic affections, however, too much stress cannot be laid upon the advisability of a careful search for the protected foci of infection, for urethral strictures, and anomalies.

The divisions of the urethra. For descriptive purposes the urethra may be divided into three portions: the anterior, pendulous or penile portion, which extends from the meatus to the bulb; the membranous, which runs from the bulb to the apex of the prostate; and the posterior or prostatic urethra, which passes through the prostate gland to the internal sphincter.

Length of the male urethra. The anterior, or pendulous part of the urethra is about 12 cm. long, but varies considerably in different individuals, as well as in the same individual at different times, according to whether the penis is flaccid or erect. Normally the urethra is elastic and varies in length as does the penis, but when acutely inflamed it does not, during an erection, stretch as easily as do the corpora cavernosa, and so there arises a painful symptom known as chordee. The membranous urethra, the part lying between the bulb and the apex of the prostate gland, is about 1.5 cm. long. The remaining portion of the urethra is known as the posterior, or prostatic, and extends from the apex of the prostate to the internal bladder sphincter and is about 3 cm. long. The prostatic division of the urethra also varies in length; in prostatic hypertrophy it may be considerably longer than normal. The man-

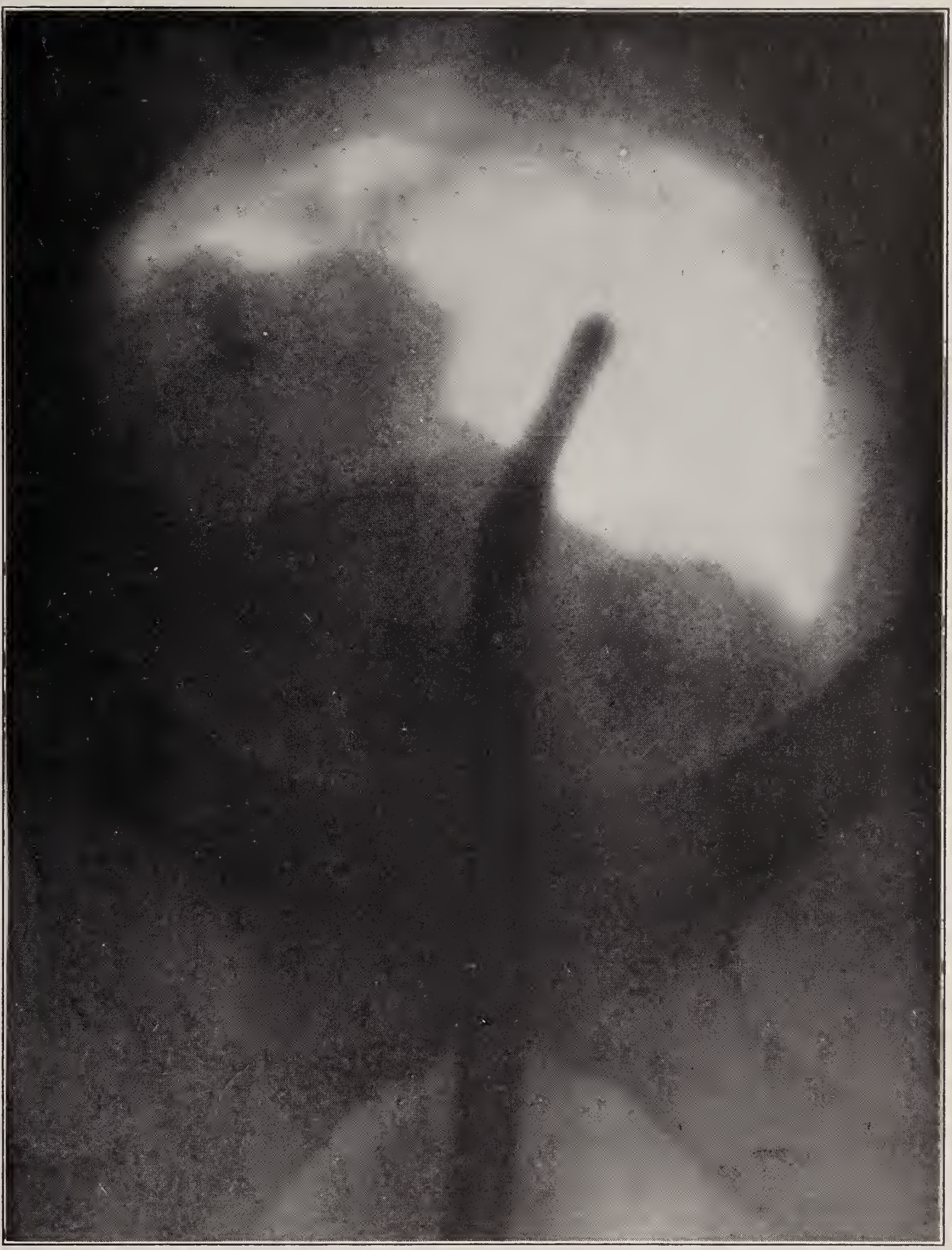

FIG. 3. Urethra lengthened by carcinoma of bladder and prostate gland. Air cystogram.

ner in which the lengthening occurs, when the prostate is hypertrophied in a snout-like projection into the bladder, is shown in Figure 2, where the length of the urethra prevented a cystoscopic examination with an ordinary cystoscope. A similar lengthening of the urethra is sometimes found in extensive carcinoma and other tumors of the prostate. Shortening of the urethra is rarely observed, though Ballenger and Elder have seen one instance in a tuberculous destruction of the internal sphincter and the underlying prostatic tissue so extensive that the verumontanum, upon cystoscopic examination, was seen to be in what then was the bladder cavity. Well-marked paralysis of the internal sphincter in tabes may result in a shortening of the prostatic urethra.

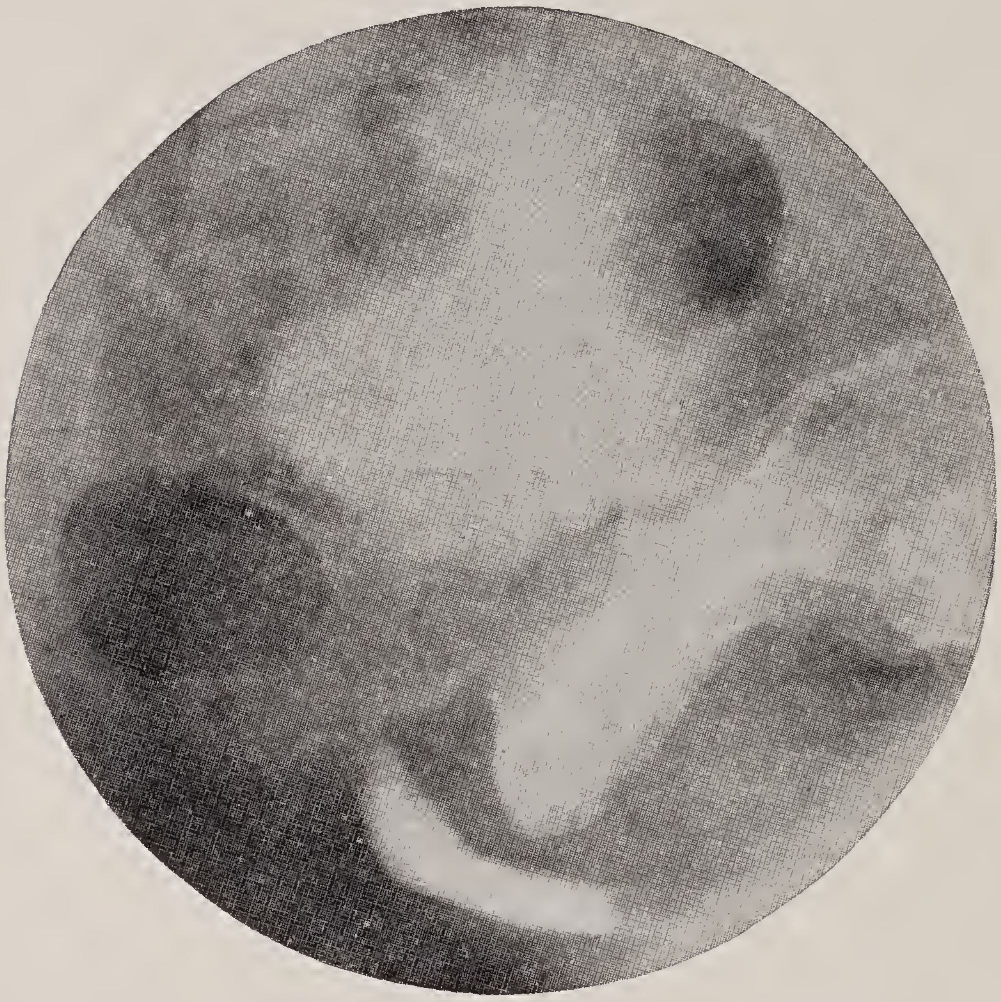

FIG. 4. Cysto-urethrogram of a cord bladder showing shortening of posterior urethra and definite relaxation of internal sphincter. After Braasch.

Course of the urethra. In normal individuals, the urethra extends along the under surface of the penis, through the bulb to the triangular ligament just beneath the bony structure forming the symphysis pubis, and on backward in the midline through the prostate to the internal sphincter of the bladder. This normal course of the urethra often is changed by perineal abscesses and other pathologic processes as well as by prostatic hypertrophy and malignant changes, sometimes pressing it well out of the midline.

Median lobe enlargement of the prostate may elevate the vesical end of the prostatic urethra so as to require curved catheters to facilitate their introduction, or if it be a cystoscope, more than normal depression of its outer end is necessary to carry the inner end " up the hill " into the bladder.

The caliber of the urethra. The circumference of the urethra varies normally in its inside measurements, from its narrowest point, the meatus, which averages about 24 to 28 F., to the posterior or prostatic urethra which is usually large enough to admit the end of the index finger and may be dilated without injury to 35 or 40 F. From the meatus, the urethra enlarges in the fossa navicularis, narrows somewhat in the penile portion, widens again in the bulbous urethra, and again narrows in the membranous part to about 25 or 30 F.

When the meatus is below normal in size, the pendulous portion of the urethra frequently is narrowed in proportion and such narrowings are designated as congenital strictures, if there is no history of inflammation, trauma, or damage by chemical agents. These congenital strictures are less frequently found in the membranous and prostatic urethra.

Hernia is more likely to occur in individuals, especially boys, when the meatus is very small, probably because of the fact that the increased, though perhaps unconscious, efforts required to void place undue strain upon the lower abdominal muscles. It seems advisable, therefore, that the caliber of the urethra be made normal where possible, before operations for hernia, both in boys and adults, in order to remove the strain consequent upon voiding through an abnormally small channel.

Another collateral fact is that when the meatus is small the openings from the ureter often are narrowed proportionately and, furthermore, that stones in the ureter and kidney, as well as hydronephrosis, are more likely to be found in individuals who have such narrow openings of the ureter. Since the penile urethra frequently shows the so-called congenital narrowings when the meatus is small, it does not seem unreasonable to suppose that the ureter above a small opening into the bladder, by the same process, developmental or otherwise, may have, or may be more likely to acquire, similar narrow points.

Paraurethral ducts. Usually at the side of the meatus, just at

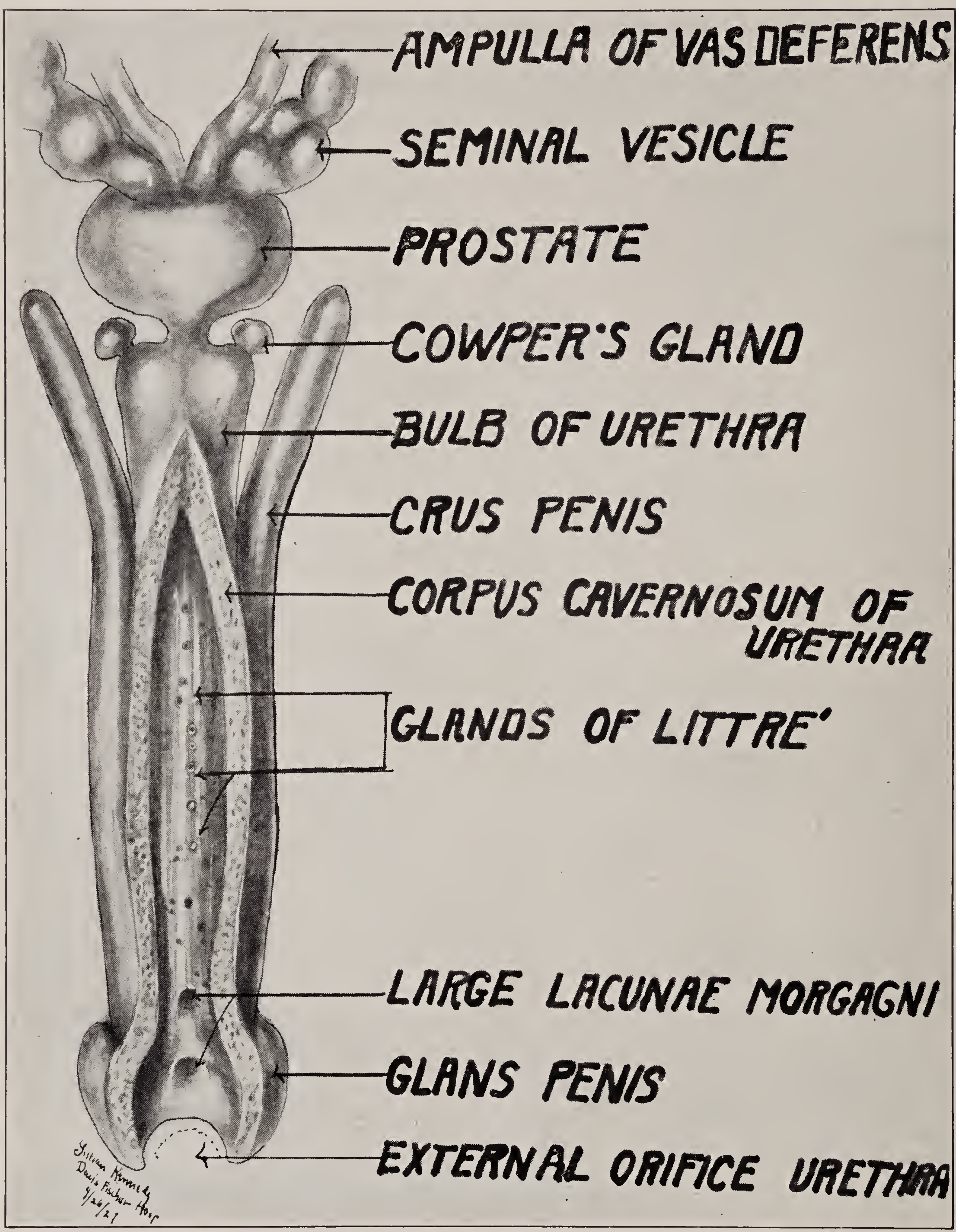

Fig. 5. Diagrammatic drawing of urethra and adnexa.

or near the mucocutaneous juncture, are seen, not infrequently, small anomalous openings known as paraurethral ducts. They lead into somewhat larger channels, which extend into the glans penis more or less parallel to the urethra and at times entering it. Generally there is one on each side, although wide variations are found in both the size and depth of these ducts and they usually are not observed until they become inflamed or become pus pockets. Sometimes they may extend to a depth of 1 or 2 cm. Their tortuous course may make it impossible to pass fine probes or filliforms through the full length of the ducts. While most of the time these ducts are in pairs, one on each lip of the meatus, they are likely to be multiple in epispadias, in which anomally they are observed more frequently than when the meatus and urethra are normal.

As foci of infection, these paraurethral ducts are often overlooked because their openings are small. Their etiology is unknown, but they differ entirely from the larger accessory urethral canals, from the lacunæ of Morgagni and from the crypts which are not infrequently the site of perifrenal abscesses. They seem, furthermore, in no way related to the glands of Littré. Only when paraurethral ducts become infected do they give trouble and, unless quite large, then are often overlooked.

The penile urethra. The extreme outer end of the urethra, the meatus, is the only part visible except with the aid of the endoscope. The penile urethra runs along the under part of the penis just beneath the skin, through which it may be palpated to its posterior part, where it terminates in the bulb. The urethra is lined with a continuous covering of columnar or cuboidal epithelium and normally its walls are collapsed. The mucous membrane, unfortunately, is not smooth but dips so as to form depressions or pockets. These are of two types: the larger ones in the roof of the fossa navicularis, which are known as the lacunæ of Morgagni; the smaller depressions, which are usually also in the roof of the channel and are known as the glands of Littré.

The lacunæ of Morgagni are usually single and are rather large pockets extending on the roof of the fossa navicularis, sometimes to a depth of 1.5 cm. while at other times they may be so shallow that they appear merely as dimples. Usually an endoscopic examination is necessary to bring them into view.

The *glands of Littré* are small pockets of mucous membrane situated generally along the roof but sometimes on the sides of the penile urethra; they are rarely found in the membranous and prostatic portion. They secrete mucus which provides a protective coating for the urethral canal. They extend into the submucous tissue somewhat parallel with the urethra, and their ducts open anteriorly. The number of these glands varies widely from none or few in some individuals to twenty or more in others. In an exceptional instance as many as forty-six of these glands have been counted. Usually the ducts of these glands will admit the tip of a number 3 or 4 urethral catheter but they are frequently found both larger and smaller. Their depth varies even more than does the size of the ducts; as a rule they are from 0.5 cm. to 3 cm. deep. If not inflamed, the openings of the glands may be difficult or impossible to see; furthermore, they cannot be detected by palpation. If they are inflamed, however, their reddened ducts are readily seen by urethroscopic examination and the inflamed nodules may be palpated; their size varies from bird shot up, the larger ones showing the usual manifestations of abscesses. Although arising from glands usually situated on the roof of the urethra, the abscesses tend to push the urethra aside and point on the under surface of the penis in the midline, differing in this respect from perifrenal abscesses. Notwithstanding the minor size of the glands of Littré, they are of major importance as foci of infection, and at times may stubbornly harbor that infection.

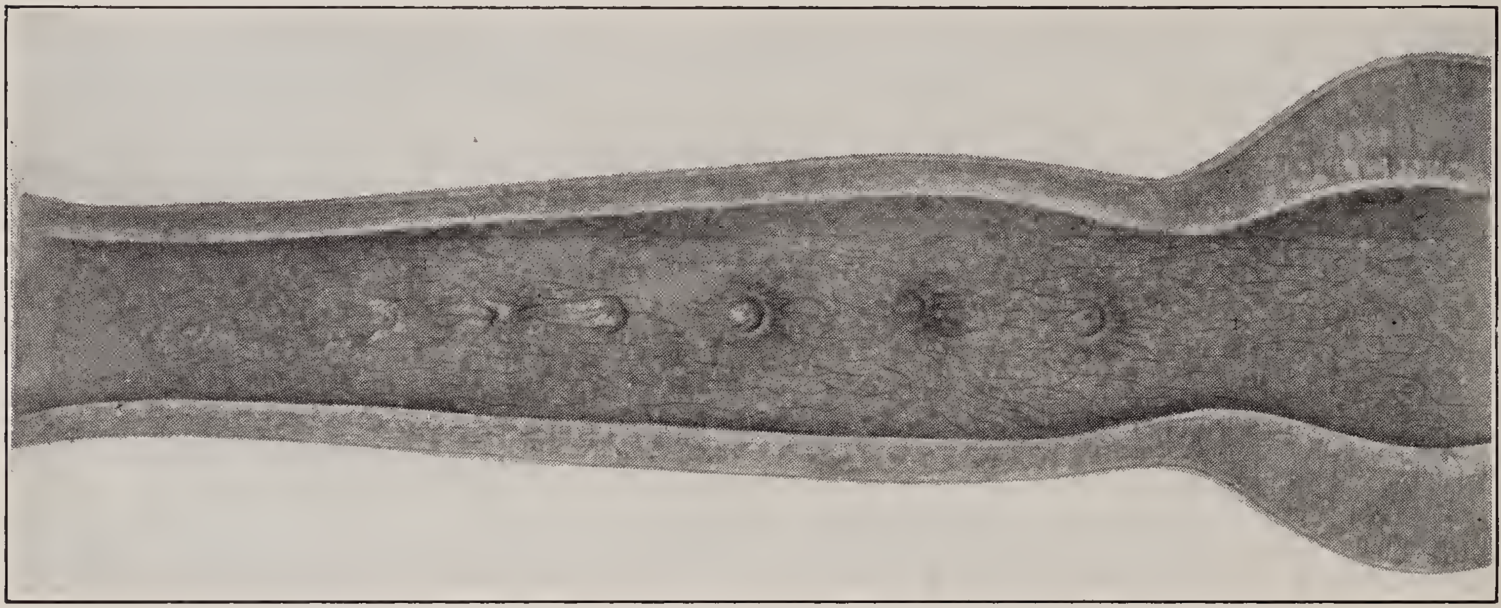

FIG. 6. Glands of Littré in the roof of the urethra.

Cowper's glands. Cowper's glands are about the size of a navy bean and are situated on each side of the membranous urethra between the anterior and the posterior layer of the triangular ligament, embedded in the external sphincter muscle. They are racemose in character and open by two channels about 0.25 cm. to 0.5 cm. long; their ducts pass through the anterior layer of the triangular ligament and open into the bulbous urethra. Cowper's glands cannot be made out by palpation unless they are inflamed;

their palpation then is facilitated by placing one finger in the rectum and the thumb on the anterior perineum over the membranous urethra. Cowper's glands are lined with columnar epithelium which secretes a clear viscid mucus-like substance, especially during sexual excitement. When suppurating, the resistance of the triangular ligaments tend to cause the pus from Cowper's glands to burrow into the ischiorectal fossa. Less frequently the pus may follow the duct through the anterior layer of the triangular ligament and point in the anterior perineal triangle.

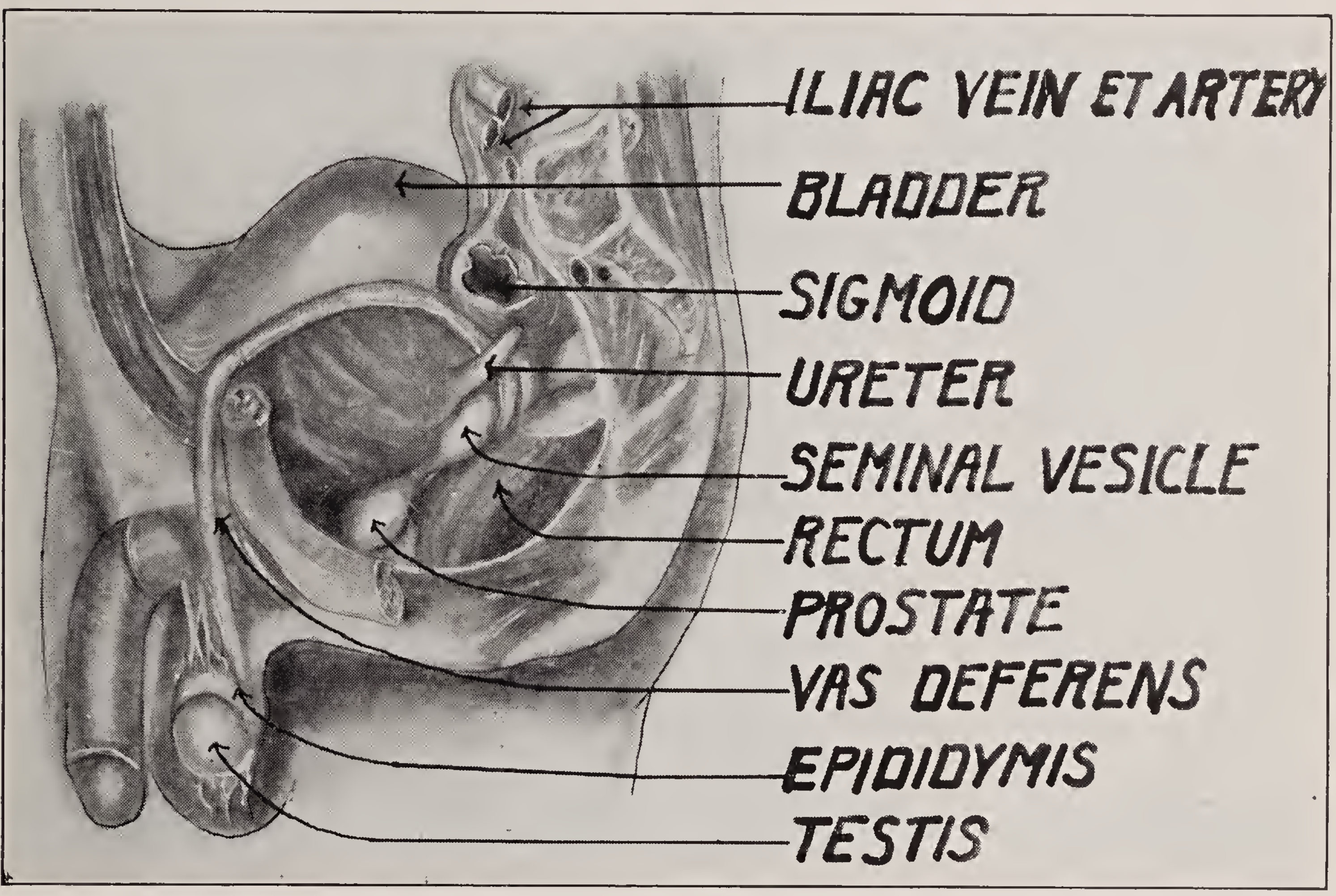

FIG. 7. Schematic drawing of lower genito-urinary organs.

The verumontanum. The verumontanum is a very sensitive elevation on the floor of the prostatic urethra. It rises gradually or abruptly on the floor of the urethra and tapers gradually from its peak backward until it merges with the urethra. The verumontanum is usually round or oval in shape when viewed from the front, and lies nearer to the internal sphincter than to the external sphincter. The size of the verumontanum varies considerably in apparently normal individuals, as well as in the same individual at different times, according to the extent and character of sexual excitement, coitus, or masturbation. It is usually larger in size and more hyperemic in those who have subjected themselves to prolonged, ungratified sexual desire. Generally the verumontanum is about the size of a pea or bean. Its color is less pink or more pink than the urethral mucosa and at times more reddish than pink, due to its greater hyperemia than that of the surrounding urethra. Its nerve terminals are highly sensitive, and when touched by urethral sounds or instruments the patient experiences a definite and peculiarly sharp pain.

The verumontanum is subject to wide variations in its size and the degree of its hyperemia, which is generally proportionate to its hyperesthesia. On the anterior (sometimes superior) surface of the verumontanum is an opening more or less irregular in shape, called the utricle or sinus pocularis. To the sides and below the sinus pocularis are the openings of the seminal ducts, smaller in size and more slit-like in shape than the utricle. The openings from the seminal vesicles will often admit a catheter or bougie 3 to 6 F. in size. The verumontanum is delicate in its structure and when hyperemic it bleeds easily; at times it is somewhat like granulation tissue. The utricle affords a protected focus for infection in the depressions of its structure and not infrequently forms a suppurating pocket, as do the glands of Littré and the prostate.

Sinus pocularis. (*Synonyms.* — **Utriculus prostaticus, uterus masculinus, vesica prostatica, organ of Weber.**) The sinus pocularis is an encapsulated, glandular organ situated in the verumontanum, and opening on its anterior or superior surface. The main or common duct leads to smaller and smaller branching ducts which finally end in glandular acini. These acini are separated by the intraglandular stroma, which is derived from, and is continuous with, the capsule of the sinus pocularis.

By making many sections of the verumontanum and including all sections in the study, Rytina made a careful investigation of the sinus pocularis, and his histological studies afford the basis of the following description of the glandular structure, ducts and capsule of the sinus pocularis.

Glandular structure. The glands vary in number, size, and shape in the different specimens. The glands are simple and racemose, or, in portions, show rather marked intra-acinous proliferation. The wall or base of the acini is composed of a flattened layer of connective tissue cells upon which are immediately apposed the cells of the acini themselves. The layer might be simple columnar or simple cuboidal in type, more often the latter. Occasionally, the cells of the acini are so closely packed that they appear somewhat squamous in type. The number of cell layers is normally 2 or 3, although, at times, owing to the way the specimen has been sectioned, it will appear as many-layered. The nuclei are small, rather rounded in shape and usually take the stain well. The protoplasm is clear and takes eosin with avidity. The lumen of the glands seem empty, but occasionally corpora amylacea are present.

Exfoliated epithelium is also seen at times within their lumen. From the manner in which the gland cells take the stain and their appearance of activity, it seemed probable to Rytina that they have an active function to perform. This was further supported by the fact that the walls of the acini showed healthy, active looking tissue, not atrophic as would presumably appear if the organ were only an embryonic rest.

Ducts. By thin serial sections it was seen that these glandular acini open by smaller and larger ducts into one grand or common duct. The latter courses obliquely throughout the entire length of the sinus pocularis, and is lined, like the smaller ducts, with the same type of epithelium as the acini themselves. The glands of the sinus pocularis, encased in their firm capsule, are seen in every portion of the organ.

Common duct. The common duct usually courses in an oblique manner throughout the entire sinus pocularis, and is lined by the same type of epithelium as the acini, and on cross section looks like mucous membrane with many invagination processes. Serially, however, it was seen that these invaginating processes are the larger ducts which receive as tributaries the smaller ducts and which in turn drain the glands themselves.

Capsule. The entire sinus pocularis is enclosed in a firm wall which, microscopically, is composed principally of fibrous tissue with a generous admixture of smooth muscle fibers.

The wall of the sinus pocularis varies in thickness in different portions. It is continuous with the intraglandular stroma of the prostate and ends insensibly in the muscular wall of the urethra. By serial sections the intraglandular stroma of the prostate can be traced and seen to form the wall of the prostatic acini, then dip between the individual acini and form their supporting framework. Similarly, it continues to form the wall of the sinus pocularis, whence it extends to form the supporting framework of its glandular acini.

Ejaculatory ducts. The wide variations found in the descriptions of the ejaculatory ducts and the verumontanum, led Mc-

Carthy, Ritter, and Klemperer to make a study of 80 specimens and more than 1,000 microscopical sections of these small organs to determine their anatomy and histology.

The utricle was found to open in the midline and the ejaculatory ducts to open antero-lateral to it in 80 per cent. of the specimens; in 5 per cent. they opened lateral to the utricle and in 15 per cent. post-lateral to it. None opened within 15 mm. of the margin of the utricle. The orifices were open and no valve-like formation was seen protecting them. The ejaculatory ducts averaged 15 mm. in length and 1.9 mm. in circumference at their orifices. The ducts became larger as they approached the seminal vesicles, at which point their average circumference was 4.5 mm. They showed a very sharp dip of 45 degrees in their course from the urethral orifice through the verumontanum to the urethral floor. They also diverged slightly and then converged until there was only a thin fibro-elastic septum separating them, which was easily perforated even when soft, flexible instruments were used. Through the prostate they ran parallel at a less acute angle, terminating at or within the substance of the gland. The lumen of the ampulla of the vas deferens measured 3.1 mm. in circumference. It opened into the duct of the seminal vesicle at an angle of 30 degrees or more, supero-mesially, to form the ejaculatory duct, this formation taking place within the prostate gland. The verumontanum had a thin layer of smooth muscle extending over it and supporting its epithelium and muscle of the urethra. It had a fibrous tissue structure intermingled with smooth muscle and contained some elastic tissue surrounding the ducts and tubules which gradually faded into the interstitial tissue of the prostate. . . . The ejaculatory duct orifice was not protected by muscle or flap tissue. Some elastic tissue followed the ducts but no definite muscle layer was associated with them. Where the ampulla of the vas joined the ejaculatory duct, definite muscle tissue was demonstrated. Venous sinuses surrounded the ejaculatory ducts. There was a large artery situated between the ducts and posterior to them. The epithelium of the ejaculatory duct was transitional, becoming columnar as it reached the prostate gland.

EMBRYOLOGY OF THE URETHRA

The urethra originates from the urogenital sinus, which also gives rise to the external genitalia by the closure of the primitive urogenital opening, the meatus coming into existence subsequent to the opening out of a groove in the solid urethral plate.

The following extensive quotation is taken from Lowsley, whose painstaking and thorough work has resulted in what is probably the best available discussion of the formation of the urethra in the embryo.

" Special study of this process of closure has shown that while the female embryo in its second and third months has an imperforate glans clitoris, in the male the glans has been tunneled by the epidermis at the apex passing in and back, thus forming a solid plug which by central desquamation eventually produces a lumen. The deep layer of epidermal cells on the surface of the glans will be seen to be continuous with those of the same layer in the urethra, and ' nests ' of such cells often fill the canal. This tunneling process continues through the tissue which in the female will eventually produce the vestibule; in the male, an orifice remains open behind the frenum and somewhat anterior to it.

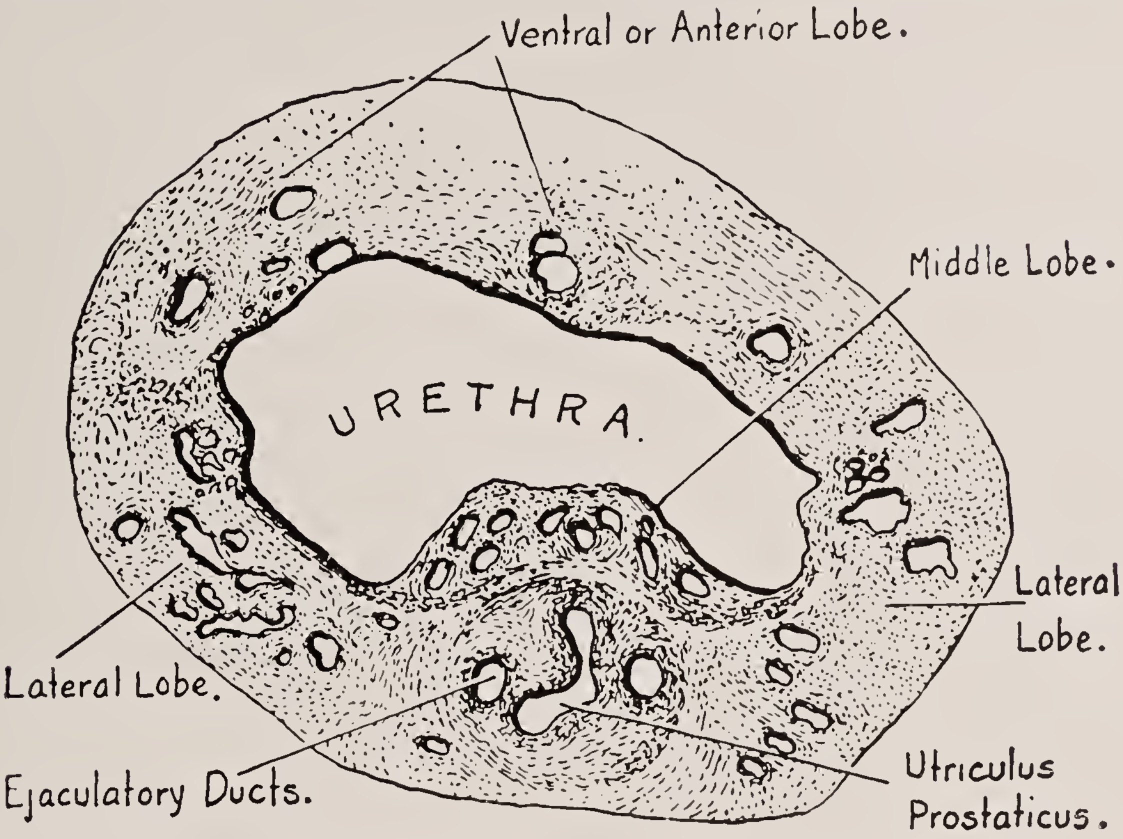

FIG. 8. Cross-section through the prostate of an embryo aged five and a half months. The tubules have developed lumina and show branches. The ducts of the middle lobe tubules are grouped together in a separate envelope on the top of the verumontanum which is formed by the ingrowth of the ejaculatory ducts with the utriculus prostaticus. (Courtesy of Lea & Febiger.)

" The epidermis continues to proliferate both on the surface and below, the deeper layer, as the cells multiply, gradually effecting closure of the opening. Thus the epidermal layer does three things in closing the urethra below: (1) it proliferates in the apertures solidly, carrying the superficial cells in its center; (2) the deeper contiguous cells unite to close any aperture; (3) the superficial epidermis proliferates over the closed apertures so as to make a surface. Finally, the central cells in the blocked urethra break down and form the lumen. Hypospadias, in its varying degrees, results from the failure of this closure."

Other investigators do not attach quite so much importance to the part played by the epithelium. According to another view the process which results in the closure of the genital groove is a mesoblastic activity spreading along the penis, affecting especially the lips of the genital groove, being, in this investigator's opinion, a direct extension of the process which results in the formation and union of the lateral fold in the entodermal cloaca. The two small projections upon the caudal boundary of that transverse slit which represent the opening of the common cloaca, termed *Analhoecker* by Reichel, who was the first to describe them, gradually curve forward and meet at the midline, and following this the lips of the urogenital opening immediately in front are drawn together and united. From this point forward to the base of the glans, a similar cavity prevails; the lips of the genital groove elongate, thicken, converge and ultimately unite in the midline to form the floor of

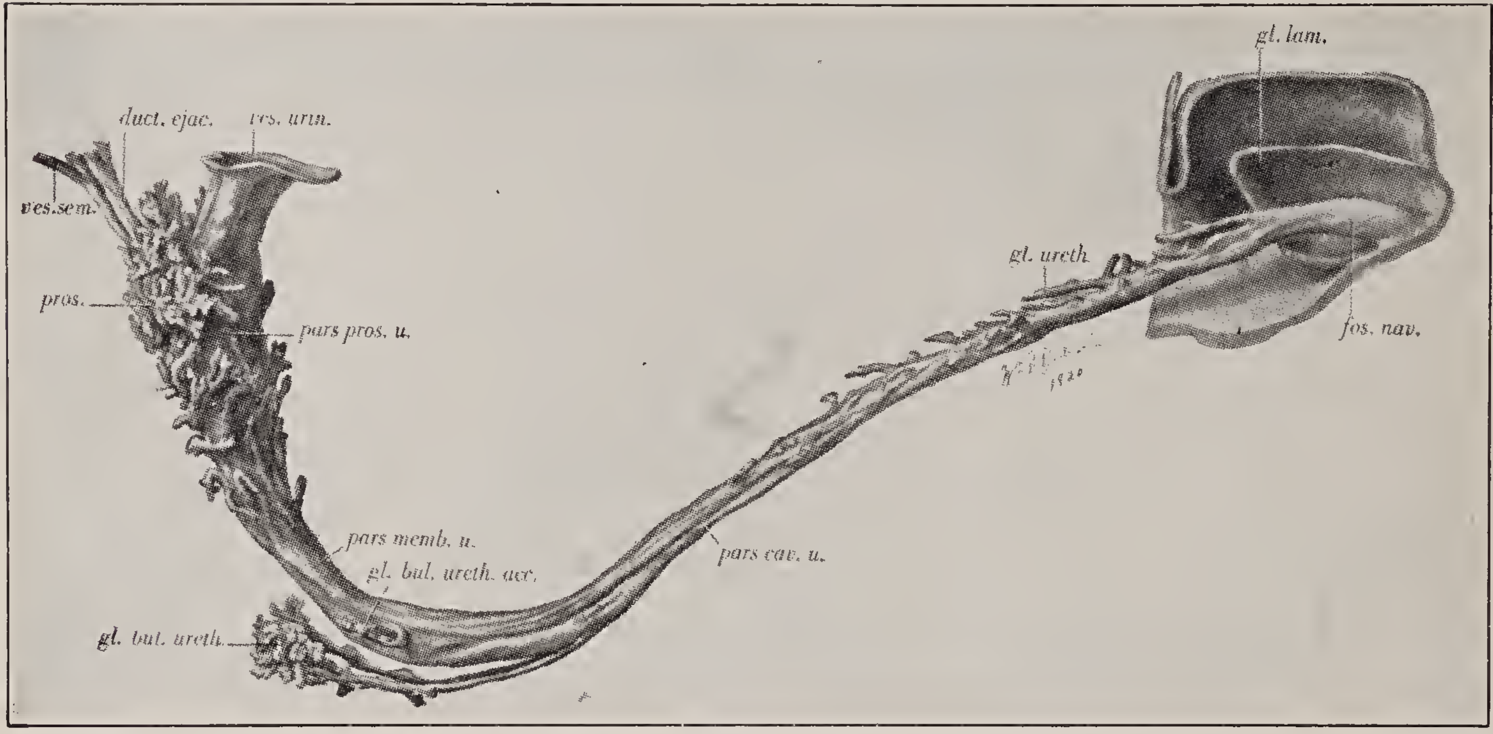

FIG. 9. Lateral view of a wax reconstruction of the urethra of an embryo of 130 mm. After Johnson. (Courtesy of W. B. Saunders Co.)

the spongy urethra. The activity spreads rapidly along the penis until the groove is converted into one continuous tube lined by epithelium from bladder to base of glans. The deeper portion of the epithelial plate or core undergoes no change for a considerable period following closure of the genital groove. It probably develops later in conjunction with the glans of the urethra and the mucosa which form its lining.

" **Development of the urethra within the glans.** During the third month of fetal life the glans and corona are gradually encroached upon by a mass of vertical epithelial cells continuous with the mass of cell-elements from which the " spongy urethra " has already been formed. At the base of the penis, however, this cell mass goes deeper, extending backward into the tissue of the penis itself. At the same time proliferation of the surface epithelium is going briskly forward, and upon the inferior surface a deep furrow develops which eventually extends into the mass of epithelial cells which has formed a " core " in the glans and gouged along its edge. Near the apex of the glans this furrow is not very deep, but as the corona is attained it descends further, deepening until it becomes continuous with that other groove already formed in the tissue of the penis proper. The frenum is formed as a bilateral structure from the lips of the sulcus in the glans during the development of the prepuce. Closure of the genital groove brings the two parts of the frenum together, and a floor for the urethra is thus completed.

" **Development of the verumontanum.** Development of the verumontanum from Müller's tubercle, which is a rounded elevation on the mid-ventral floor of the urogenital sinus, takes place about the 14th week of intrauterine life. The verumontanum at this period is indicated only by this rounded elevation on the floor of the prostatic urethra, the presence of which is due to the upward growth of the ejaculatory ducts. Here also will be found a closed sac-like cavity which is to be the prostatic utricle.

" **Formation of the tubules.** From recent investigations we learn that definite glandular tubules communicating with the posterior urethra appear at the periphery of the verumontanum about the 14th week of fetal life. These tubules have their origin in the invaginations of the mucous covering. Two weeks later a second group of tubules has appeared. These take their rise in the suburethral portion of the middle lobe of the prostate. They lie just below the outer stratum of the tubules previously formed, and communicate with the urethra about the middle of the third of the verumontanum. The upward slanting course of the ejaculatory ducts is apparently a factor of considerable importance in pushing these tubules upward toward the collicular prominence.

" Tubules originating in the utricle appear about the 25th week. They are found largely in the anterior portion of the utricle, their starting point being an invagination of the wall of the prostatic urethra.

" These three sets of tubules can be plainly identified by the 31st week and by this time the prostatic utricle will be found in communication with the posterior urethra, the opening being situated at the summit of the verumontanum. A well developed stroma is now discernible between the tubules, similar to that found in the prostate, which encloses and supports all the glandular elements of the colliculus seminalis. Thus at birth the tubules originating in the mucous membrane are found in the upper third near the internal sphincter of the bladder, lying parallel to the urethral floor with their blind ends pointing backward toward the bladder, and all opening through the sides or top of the verumontanum into the prostatic urethra.

" The tubules arising in the prostatic region occupy the middle third of the organ, their blind ends well within the deeper tissue, but lying in an upward and outward direction, so that their orifices open along the sides of the verumontanum, or, occasionally, in front of those of the utricle or ejaculatory ducts.

" The third group of tubules arising from the periphery will be found at birth practically parallel to the floor of the urethra, their blind ends toward the internal sphincter and their termination in the orifice communicating with the cavity of the prostatic utricle."

INFLAMMATION OF THE URETHRA

A frequent affection occurring in man is inflammation of the urethra, or urethritis; this is generally classified as specific or non-specific, according to whether gonococci or other organisms are the cause of the urethritis. There are several subdivisions of inflammations of the urethra: those caused by chemical agents, by trauma, and by foreign bodies. Ulcerative lesions extending from the meatus for some distance into the urethral canal are rather rare and should not be classified as urethritis. Urethritis is usually designated acute or chronic, according to the duration as well as to the character of the inflammation. Chronic urethritis generally indicates a condition which lasts for 8 or 10 weeks or longer. At times, recently acquired affections may be mild in character like the chronic ones, while long-standing conditions may develop recrudescences with symptoms like the acute. The outstanding fact to ascertain in acute conditions is whether gonococci are present or absent, while in chronic ones the chief concern is to determine if there is a protected focus of infection or a stricture of the urethra.

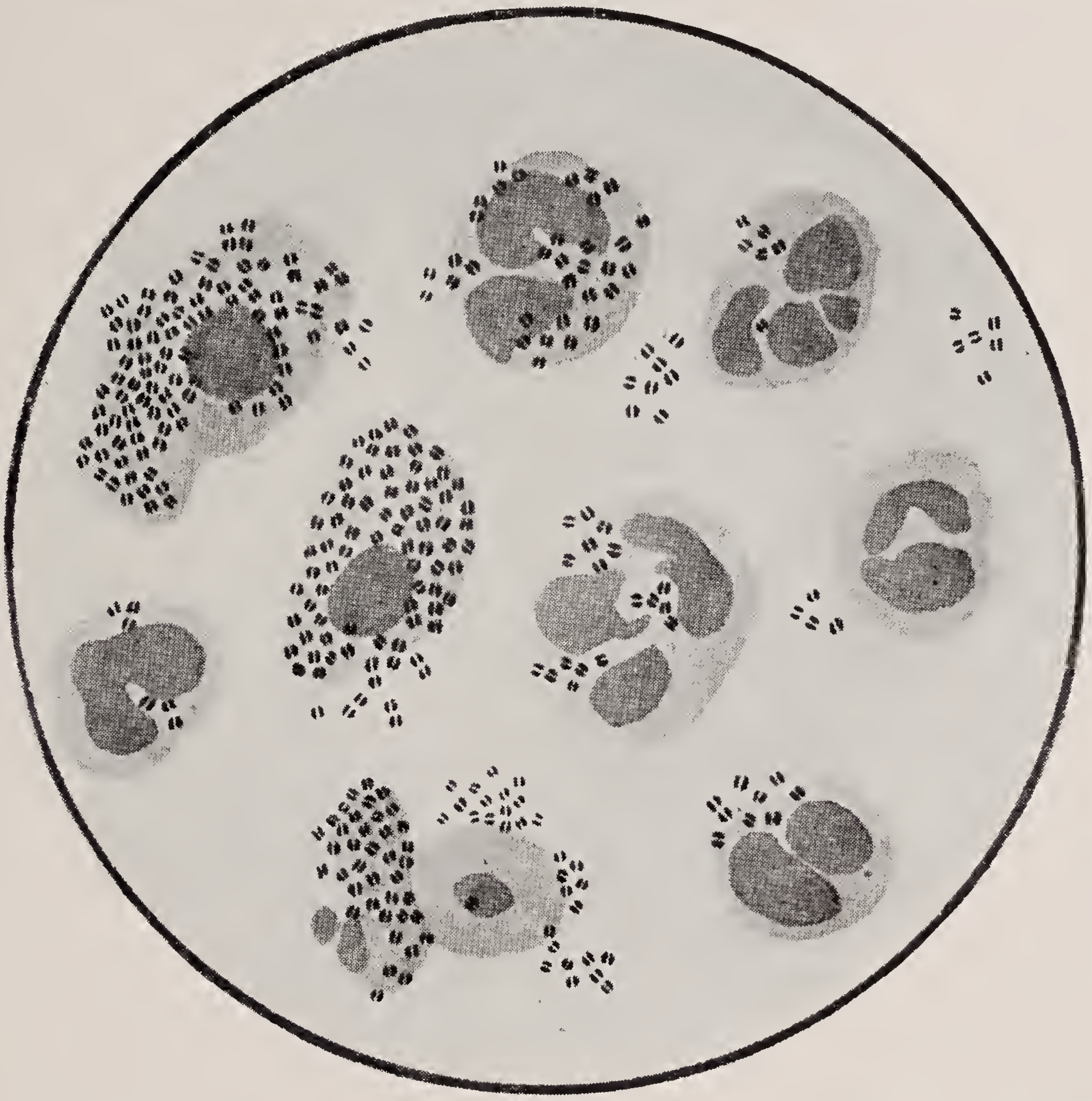

FIG. 10. A schematic drawing of gonococci emphasizing their intracellular and diplococcic characteristics.

With ordinary treatment and care for a reasonable period of time, natural immunity will overcome the average infection unless there is a protected focus or an obstructive lesion of the urethra, such as a stricture. Consequently, in acute inflammations, *infection* or *chemical injury* is first suspected, while in chronic conditions a *nidus of infection* or a *stricture* is more likely.

There is still another type of urethritis, designated as subacute; it is milder than the acute but more severe than the chronic inflammation. It approximates an acute inflammation after the more active symptoms have subsided, or a chronic inflammation with a mild exacerbation.

Urethritis is also spoken of as anterior and posterior, according to the extent of the inflammation. This classification is of doubtful value in the treatment of urethritis because incipient infections are nearly always limited to the anterior urethra but nearly always extend to the deep urethra, that is, extend beyond the external sphincter which offers no obstruction to such an extension. The infection may be present in the deep urethra for a considerable time without showing symptoms which would lead the patient to think that the organisms have reached this part of the urethra. The last part of the urine voided may remain clear when the deep urethra is involved unless the amount of pus given off is sufficient to discharge through the internal sphincter into the bladder. There is no way of knowing just when the infecting organisms reach the deep urethra; this event usually cannot be ascertained until the inflammation caused by the infection has produced pus in sufficient quantity to be detected in the specimen voided by the patient after the anterior urethra has been irrigated.

It is sometimes stated that constitutional or environmental conditions may be the cause of urethritis. Such urethritis will not persist, however, when all of the local causes of urethral inflammation have been eradicated. Systemic disturbances, alcoholism, and sexual excess may make worse an already existing condition but will not keep up a chronic urethritis unless one or more of the usual causes of such inflammation is present.

Acute urethritis of gonococcal origin. Acute urethritis of gonococcal origin, an inflammation of the urethra due to the gonococcus, is often spoken of as specific urethritis, gonorrhea, or blennorrhagia. Historical records show that gonorrhea has existed since an exceedingly early date. Moses laid down laws for the Israelites to be governed by in the management of "running issues," which are thought to have been the result of gonococcal infection. Much confusion existed even to a rather late period in history as to the nature and etiology of this disease; at first it was believed to be a "flow of semen," as a literal translation of gonorrhea indicates. Later came its confusion with syphilis. In settling the identity of these two diseases there arose, in the medical world, prolonged and heated discussions during the 18th and 19th centuries. To the French syphilographer, Ricord, is given the credit of making the distinction between the two affections. Later, Bassereau established the difference between a chancre and a chancroid. Finally, Neisser, of Breslau, in 1879, identified the gonococcus as the cause of gonorrhea and a clearer conception of the so-called venereal diseases soon led to more rational and more effective treatment. The rôle of the gonococcus in producing widespread destructive lesions in the pelvic viscera of women was soon better understood, and now it is common knowledge that gonorrhea is the primary cause of a high percentage of abdominal operations in women. The gonococcus also produces a large percentage of the genito-urinary affections and of sterility in both men and women.

Bacteriology of the gonococcus. The gonococcus of Neisser is now considered by all genito-urinary surgeons to be the cause of gonorrhea. It is a diplococcus, found in pairs, and in shape resembling a coffee bean. Gonococci multiply by fission and the line of cleavage is at right angles to the fine cleft separating them. A further important characteristic of Neisser's gonococci is that they tend to be found within the protoplasm of the pus cells, but not within the nuclei; on account of this tendency, they are designated intracellular.

Smears for microscopic study. To determine if the urethritis is of gonococcal origin a specimen is usually obtained by pressing or milking the anterior urethra. If discharge appears, it is spread as a thin smear on a glass slide. Drying the specimen in the air is usually sufficient for fixation. If a specimen cannot be obtained from the meatus, shreds may be fished from the urine and spread upon a slide, or a centrifuged specimen of the pus in the urine may be employed. The prostatic secretion and the semen are valuable in determining the presence of pus cells, but are of less value in searching for gonococci, and negative findings are not to be relied upon. If a suitable smear cannot be obtained from the meatus or urine, the patient should be given a slide and requested to spread the morning drop in a thin smear over the slide and bring it on his next visit. In chronic affections or in doubtful or quiescent infections, urethral instrumentation with sounds or a Kollmann dilator may assist, at times, in obtaining an adequate discharge. Injections of silver nitrate in 1 to 2 per cent. solutions may be required to secure a satisfactory smear from patients who are thought to be cured and who desire to marry.

Methylene blue staining for gonococci. The dried specimen is stained for about five seconds with a saturated aqueous solution of methylene blue, then washed in running water, dried and examined with the oil immersion lens for gonococci. The organisms are stained a dark blue, occur in pairs, and are mostly within the protoplasm of the pus cells. The presence of intracellular diplococci in the discharge of acute urethritis, following a recent exposure, leaves little or no doubt as to the diagnosis. If, however, the incubation period has been longer than ten days and if other atypical facts are brought out in the history, or if the discharge has been recurrent, like that associated with urethral strictures or chronic prostatitis, additional staining and observation should be employed before a positive opinion is expressed.

The gram stain. The gram-staining method divides microorganisms into two groups: those which retain the initial stain, and those which are subsequently decolorized and take the counter stain; the former is known as gram-positive and the latter as gram-negative.

The micrococcus catarrhalis, atypical colon bacilli, and certain other atypical gram-negative organisms may be present in the protoplasm of the pus cell and at times may so resemble the gonococci morphologically that a positive diagnosis may not be possible even with the gram stain, and a culture of the organisms or subsequent observation and study of the clinical characteristics of the infection becomes necessary to determine the type of infection.

The gram-staining method. This is one of the most important staining methods in bacteriologic technic, but if carried out in a loose, inaccurate manner it may be worse than guessing. In the hands of inexperienced workers, it is likely to give unsatisfactory results. The following requirements are advised: the specimen should be fresh; the aniline gentian violet should be kept in a dark bottle and old solutions should not be used; the color should be a rich violet; the iodine solution, which deteriorates with age, should be of a dark port wine color; the smears should be thinly and evenly spread; the decolorization should be stopped as soon as the violet stain ceases to "stream out from the preparation." This observation is best made over a white background.

Technic of the gram stain. Success with this stain requires precision in each step. The smear is air dried and passed through a flame for fixing. The aniline gentian violet solution is applied for 3 or 4 minutes and washed off with water. On account of its greater stability and quick staining, carbol-gentian violet may be employed instead; it is prepared by adding one part of a saturated solution of gentian violet in alcohol, 95 per cent., to 10 parts of a 5 per cent. carbolic acid solution in water. This will give adequate staining in one minute or less, if the film is thin. The iodine solution is then applied for 2 minutes. Unless the smear has the color of coffee grounds, the iodine solution is reapplied. The iodine solution is washed off and the film decolorized with acetone or alcohol, 95 per cent., until no more of the violet color streams out; the time required depends upon the character of the smear and upon its thickness. It is again washed and counter stained as desired. Gram-positive organisms are stained a deep violet, whereas the gonococci or other gram-negative bacteria, or cocci, take the counter stain.

The culture of the gonococcus. In routine work where the diagnosis for treatment alone is required, the methylene blue and gram stain are sufficient. However, in divorce cases, rape, or other instances of medico-legal importance, where it is necessary or desirable to establish the diagnosis beyond the question of doubt, cultures should be made to isolate and identify the organisms. Owing to the difficulty experienced at times in growing the gonococcus, control cultures of known gonococci should be made along with the test cultures. The failure to detect gonococci by any culture method should not be relied upon alone to verify the cure of gonorrhea but should be supplemented by clinical tests, microscopic tests, time tests, complement-fixation tests, etc.

Collection of material for tests. The patient should report for examination with a full bladder. After washing the glans penis well, a 3 per cent. aqueous solution of mercurochrome is applied to and around the meatus; sterile gauze is placed over the penis and ten minutes time allowed to lapse; a clamp is placed on the penis, and then the prostate gland and seminal vesicles are firmly massaged. The sterile dressing and the urethral clamp are removed and material from the expressed secretion is transferred to the culture medium. The urine is voided into a sterile container, and other specimens are obtained from the urine containing the remainder of the expressed secretion. Sterile centrifuge tubes are employed and plugged with sterile gauze or cotton. The centrifuge is allowed to run for 15 minutes and, if the amount of the sediment seems inadequate, the supernatent urine is poured off, more urine added and centrifuged for 15 minutes. Part of the sediment is used for smears, which are fixed and stained with methylene blue and by the gram method. The remainder of the sediment is kept at body temperature until transferred to the culture medium and inoculated. The transfer should be made as promptly as is feasible.

The culture media for the gonococcus. The gonococcus will not grow readily on the ordinary laboratory media and the occasional positive cultures obtained from a discharge are due to the fact that sufficient albuminous material is carried to the media by the exudate. Great care is required in the culture of the gonococcus. Apparently the best technic of growing the gonococcus is the Leahy-Carpenter modification of the McLeod method. "The method consists in making cultures on 'chocolate' agar, prepared with a Douglas agar base, and incubating them at 34 degrees C. and at 37 degrees C. in an atmosphere of air reinforced approximately to 10 per cent. in its carbon dioxide content. The oxydase test, employing a 1 per cent. aqueous solution of dimethyl-paraphenylenediamine hydrochloride, is used to identify gonococcus colonies in mixed cultures". Concerning this technic Carpenter, Leahy and Wilson say: "Although the cultural method for the diagnosis of gonococcal infection in the male has, in our hands, proved to be more reliable than the smear method, it does not show the marked superiority that is observed in the case of the adult female. The smear method in the male is more dependable, because the male genito-urinary tract does not harbor so many bacteria nor such a profound inflammatory exudate as the lower birth canal. It is advisable, nevertheless, to employ both methods in the male, especially when an adequate test for cure is the objective."

Etiology of gonococcal urethritis. In the majority of instances, gonococcal urethritis in the male is contracted during coitus with a female who has gonorrhea. Not always, however, will an examination of the woman enable one to find gonococci, for the organisms may be deeply seated in the tubes or elsewhere in foci inaccessible for obtaining smears. The mere fact that the woman submits to a negative examination or can show a certificate alleging that she is free from gonorrhea does not mean that such infection is absent, but indicates only that the medical examiner was unable to find gonococci. Women are more likely to have quiescent infection than are men, the immunity being sufficient to control active lesions and to prevent the exudation of adequate secretion bearing the infection to demonstrate the organisms. At times a woman with a latent infection seems more infectious than at others. The menstrual period apparently increases the danger, bringing outward organisms that at other times may remain in protected foci; the most likely time, therefore, for infection to be contracted is just after the menses. By the same reasoning, this is the best time to make an examination for gonococci. Even when the history proves beyond doubt that a woman has gonorrhea, the organisms sometimes cannot be found except by culture or in the discharge of the men whom she infects.

At one time, medical men were inclined to believe that the male might harbor gonococci for 5, 10 or 20 years and then develop an acute exacerbation like a recently contracted gonorrhea. There is no probability, however, of the existence of such a condition. In every instance, if the patient tell the truth, a history of a direct or accidental exposure may be ascertained. When the patient denies exposure, the surgeon should explain that he greatly regrets that the infection is old instead of new as the plan of treatment is totally different; that it is perhaps possible to cure a recent infection quickly while one of long standing requires a much slower treatment. When the situation is so explained, the patient will usually say that sexual intercourse was indulged in recently but that the woman was so far above suspicion he felt sure that there was no infection possible and that he did not regard it as an exposure. In men, accidental infection not associated with coitus, partial coitus, or attempted coitus is so unusual that it may be disregarded.

Symptoms of acute anterior urethritis. The incubation period of gonorrhea is usually from 4 to 6 days, but occasionally it will be as short as 2 or as long as 12 days. If the discharge appears within 2 days, or earlier, a recurrence of a latent infection may be suspected if gonococci are found; but if absent, it may be assumed that the discharge is from trauma, excessive indulgence in sexual intercourse (the so-called strain), excess of alcohol, prophylactic remedies, urethral strictures, chronic inflammation of the prostate gland, or of other structures connected with the urethra which act as foci. In case the foreskin is long and cannot be retracted, discharge from a balanitis may in a way simulate urethral discharge and mask the source of the secretion. This confusion need be of short duration, however, if the cavity under the foreskin is irrigated before the patient voids; the quality of the urine then passed shows at once by the presence or absence of pus whether the inflammatory process involves the urethral mucosa.

Extension of the gonococci. A slight itching or burning during or after urination is usually the first symptom of gonorrhea the observant patient will notice. Coincident with this is a slight redness and edema of the meatus. These symptoms grow worse, sometimes slowly, sometimes rapidly. Usually in a day or so there is more or less sharp burning on urination and the meatus is quite sensitive. The rate at which the inflammation increases depends upon the number of previous infections, the character of the immunity, natural or acquired, the size of the meatus, the age of the patient, and perhaps on the type of the gonococci, whether of an attenuated or of a vigorous strain.

The height of the inflammation in the anterior urethra is characterized by four cardinal symptoms: discharge of pus, red meatus, burning on urination, and painful erections. These symptoms are greatly modified by the promptness and character of the treatment employed, as well as by the type of the urethral mucosa. The serous character of the discharge as first seen soon changes to thick creamy or greenish pus, sometimes tinged with blood. The amount of the discharge varies with the intensity of the inflammation, the frequency of the urination and with the treatment. Typical intracellular gram-negative diplococci are present in large numbers in the smears of the urethral pus. The epithelial cells are scanty compared with the number present in the beginning, and polymorphonuclear pus cells dominate the field. As the disease reaches the subsiding or chronic stage, the discharge contains more mucus, more epithelial cells and more mononuclear cells.

The redness of the meatus varies from the mild conditions where there is only a pink circle around the meatus to the hyperacute cases involving a considerable portion of the glans penis around the meatus, which is edematous and sensitive; the prepuce may be swollen and red, and phimosis, paraphimosis, balanitis, or balanoposthitis may develop. The intensity of these acute symptoms does not vary in proportion to the time required for the patient to obtain a cure, but rather the reverse may be true; the more severe the symptoms, the earlier the immunity is likely to develop. This affords a little consolation to the patient during the time of the hyperacute period.

Chordee or painful erections often occur in patients who are slow to start appropriate treatment. This symptom is due to the inelasticity of the urethral mucosa and corpus spongiosum occasioned by edema and inflammatory infiltration. The corpora cavernosa, when distended, pull upon or stretch the inflamed corpus spongiosum which, being sensitive and less elastic than normally, results in pain, a bending downward of the penis and sometimes bleeding. The trauma thus occasioned and its subsequent healing by scar tissue nearly always terminates in a stricture of the urethra.

Painful urination usually varies with the redness and swelling of the meatus and is usually worse upon starting and while the urine is passing. It differs in this respect from the pain caused at the end of urination when the inflammation has reached the deep urethra and prostate gland.

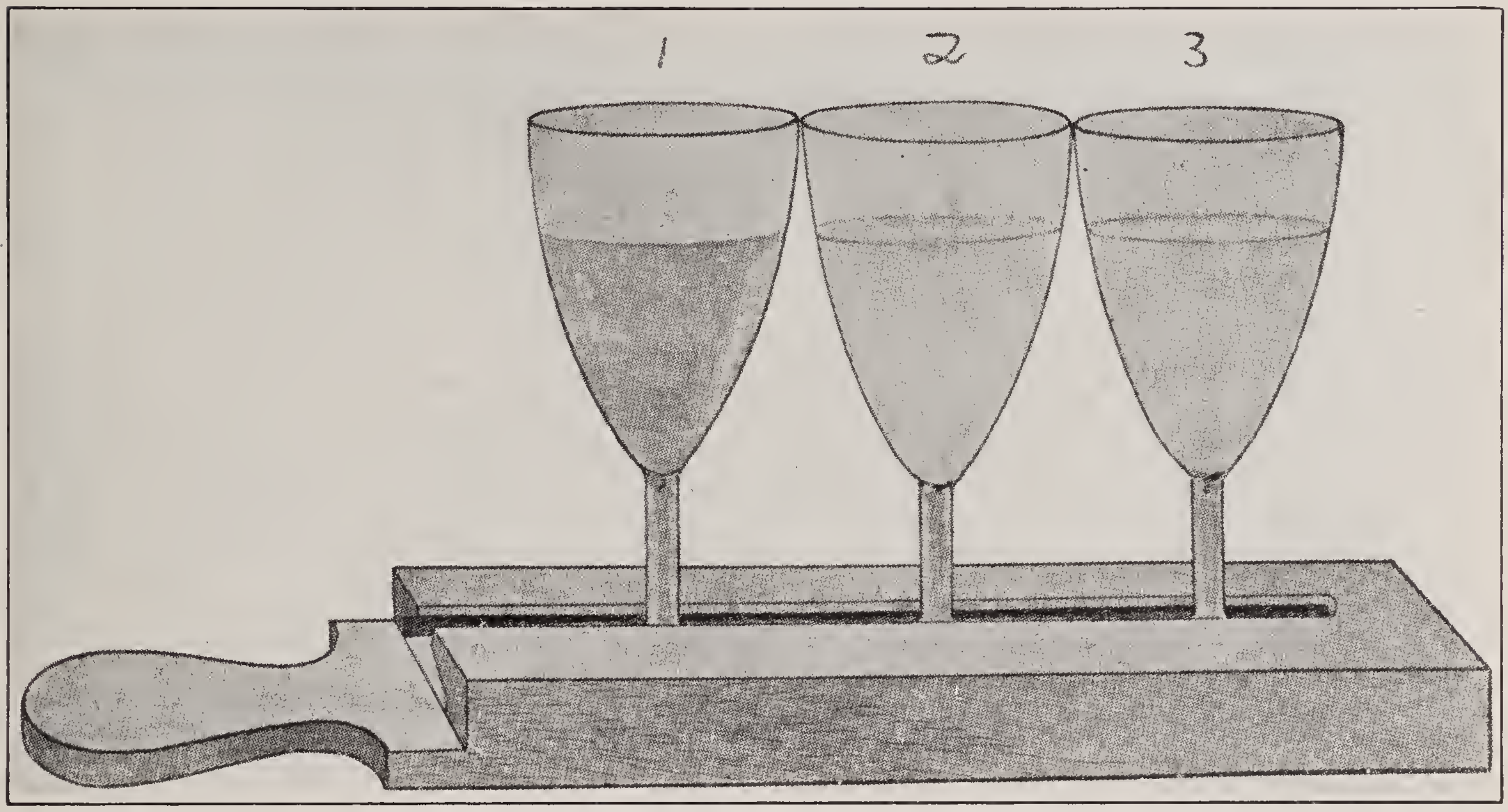

FIG. 11. Acute anterior urethritis — first glass cloudy, second and third clear. The same thing may occur when the posterior urethra is inflamed, when the pus is too small in amount to flow back into the bladder.

Changes in the appearance of the urine depend upon the degree of the inflammation and upon its extent. In the beginning, there is only a slight cloudiness and a few shreds of mucus and pus in the first glass. Soon the first glass becomes distinctly cloudy with pus and shows heavy shreds. Later, as the inflammation subsides, the shreds become longer and lighter, float higher in the urine and settle less quickly to the bottom of the glass than do those composed largely of pus. When complications such as deep urethritis or prostatitis occur, all the glasses of urine may become cloudy and frequent urination develops. Acute or hyperacute inflammation of the deep urethra and prostate may result in terminal hematuria, difficult urination, or complete retention of urine.

The acuteness of the symptoms of gonococcal infections vary to a marked degree even in patients taking the same treatment. The longer the infection takes to become established in the prostatic urethra, the less acute, as a rule, are the symptoms of posterior urethritis. While immunity appears to be the controlling factor in properly treated acute conditions, other factors of prime importance in the subsiding stages and chronic conditions are focalized infections and urethral strictures. Such considerations, however, should not lead one to early and overzealous efforts with urethral investigations until the usual measures have been employed long enough for the patient to develop a considerable degree of immunity.

Three-glass test of urine. At each visit the patient is requested to void into three glasses in order to determine the progress in the treatment, or the extension of the organisms to the posterior urethra. In order to make an intelligent interpretation of the urinary findings, it should be remembered that turbid urine may result from pus, phosphates, urates, micro-organisms, and medicine employed as injections, such as colloidal silver salts. If the first glass alone be cloudy, it is usually due to the presence of pus cells or recently injected medicine.

Confusing factors may arise from multiple affections. For instance, a patient with a stone, or tuberculosis in the genito-urinary tract, or one with a chronic urethritis, prostatitis, or urethral stricture, may acquire a gonococcal infection. The history of the condition before the acute onset and a study of the stained sediment of the last glass of urine will usually enable one to recognize such complicating affections if even reasonable care be exercised in the examination and history taking.

Diagnosis. The foregoing symptoms and a history of a recent sexual exposure, followed in a few days by the inflammatory area at the meatus and urethral discharge which shows gram-negative, intracellular diplococci, leaves practically no uncertainty as to the diagnosis of gonorrheal urethritis. Not in every instance, however, are conditions so definite. It may be that there is doubt as to the cure of an old or a recent gonorrhea and the patient may desire to know particularly if it is a new infection or a recrudescence. The incubation period is of value in reaching a conclusion unless there have been multiple exposures at such close intervals that uncertainty exists as to which one afforded the source of the infection. A very short or an extra long period of incubation probably indicates that the infection is old and that the discharge is a recrudescence.

Non-specific urethritis is diagnosticated by the absence of gonococci in the urethral discharge. This type of urethritis may be due to trauma, prophylactic measures, chronic urethritis, prostatitis, etc., and a single negative examination should not be relied upon for the obvious reason that gonococci may become evident at a later date. At least two weeks should elapse after an exposure before expressing positively an opinion that the urethritis is non-specific, regardless of the presence of urethral stricture, chronic urethritis, prostatitis, or the history of the injection of a strong prophylactic remedy. Agents injected to prevent infection may produce at once a chemical discharge creating a misleading history, but perhaps only delaying the growth of gonococci. In view of this doubt, it is advisable to postpone treatment until the affection progresses to the time when a positive statement may be made.

In chronic urethritis with a recurrence, the incubation period is usually short or long and the acuteness of the symptoms, as a rule, subsides quickly.

The differential diagnosis of balanoposthitis and phimosis requires an irrigating wash to clear the subpreputial space of secretion and pus before having the patient urinate; if the urine then is clear, it indicates the absence of urethritis which would be present in case gonococci were the infecting organisms. On the other hand, if the urine is cloudy with pus, a centrifuged sediment should be dried, stained and examined. Subpreputial, ulcerative lesions may be differentiated from gonorrhea in the same manner.

Chancre at or just within the meatus may cause a discharge occasionally resembling incipient gonorrhea. The absence of gram-negative intracellular diplococci is usually sufficient to prove that it is not gonorrhea, but in case the patient has a gonococcal urethritis and also a chancre of the meatus, delay in recognizing the latter lesion may result. The edema of the meatus in gonorrhea never has the hardness of the chancre, but is more sensitive. Ulcerations of the meatus and urethra do not result from gonorrhea. Chancroids of the meatus are recognized by their characteristics.

The gonococcic complement-fixation test. This test is not expected to become positive in anterior gonorrheal urethritis in the male or in vulvovaginitis in the female, but rather when complications and deeper extensions of the organisms arise. It usually requires about one month, though a positive reaction may be obtained earlier, especially if the infection become extensive. In this respect, the complement-fixation test of gonorrhea resembles that of syphilis, but as a help in practical work, in the latter, it is of far greater value. A positive test usually disappears in from 6 to 8 weeks after the patient is cured, but may disappear earlier.

The final cure cannot be stated as certain unless the clinical symptoms, negative smears and negative cultures are in line with the complement-fixation test. This test may be of value in differentiating gonococcal arthritis from other confusing affections.

Pathology of acute and chronic gonococcal urethritis. After the implantation of gonococci within the meatus, an incubation period, varying from 3 to 6 days, usually elapses before there are sufficient organisms present on or in the urethral mucosa to bring about pathologic changes. Hyperemia develops and is soon followed by emigration of leucocytes, resulting in a discharge consisting of pus, serum, gonococci, and desquamated epithelial cells. The meatus is edematous and reddened, and the mucous membrane of the urethra loses its shiny appearance and becomes thickened. The crypts of Morgagni and the glands of Littré undergo the same changes. Within a few days, the process is well under way, the inflammation having extended as the gonococcic invasion proceeds; the organisms penetrate the epithelial cells and the spaces between them. The toxic material produced causes leucocytes to accumulate in, and exude through, the damaged epithelium, which undergoes a " mucous degeneration " and exfoliates in small patches. As the disease progresses, the mucosa becomes thickened with embryonic cells, loses its elasticity, and bleeds easily. The subepithelial connective tissue is inflamed but fails to show gonococci except where the process is most active around crypts and urethral glands. Infiltration near the openings of the glands of Littré may close them, converting their cavities into pus sacs. These vary in size from bird shot to walnuts and may undergo resolution or may increase in size and require incision; or, if left alone, they may rupture either into the urethra or externally through the corpus spongiosum and skin. The abscesses in the penile urethra usually point toward the midline while those near the frenum point to the side of it. Owing to the wide openings in the crypts of Morgagni they rarely permit the accumulation of pus.

There is not infrequently edema of the foreskin, due to involvement of the lymphatic channels which run along the dorsal artery of the penis in the midline and may be felt as a hard cord just beneath the skin. A *perilymphangitis* sometimes occurs and is recognized by the redness and slight tenderness in the skin over the lymphatic canals. Less frequently, there is involvement of the small lymphatics which causes considerable pain and redness not unlike erysipelas in appearance. If the foreskin is withdrawn and forms a constricting band, the edema may increase greatly in the glans penis and in the foreskin anterior to the constriction, making it necessary to remove this edema by pressure to enable the foreskin to be pulled over the glans. In case there is extreme swelling, and the constricting band is not relieved by incision, if the foreskin cannot be sufficiently reduced by pressure, strangulation and gangrene may result. The lymphatic nodes in the inguinal region may become moderately enlarged and tender but suppurate infrequently. If paraurethral glands are present at the meatus, they are almost certain to retain pus and form small abscesses which usually require incision, as their ducts opening on the skin near the meatus are too small for adequate drainage or medication.

In most cases which are not immediately cured, the gonococci extend to the membranous and deep urethra. The pathologic process is much the same as is seen in the anterior urethra, except that the chief structures for collateral invasion are Cowper's glands, the utricle, the prostate gland, the seminal vesicles, and the epididymis. Infection of a Cowper's gland may terminate in abscess formation, generally pointing in the perineum in the region of the bulbous urethra. Enlargement of Cowper's gland is detected best by placing the forefinger in the rectum and the thumb on the perineum in the region of the bulb. The gland may thus be pressed upon and occasionally, when inflamed, pus may be made to exude if the ducts are not blocked by the inflammatory changes. The prostate gland surrounds the deep urethra and opens into it by many ducts, some large, some small; consequently, a certain amount of involvement is sure to take place when the prostatic urethra is inflamed. The degree of the inflammation may be so mild that it amounts to little more than urethritis, or the prostatitis may be so severe that it will cause retention of urine or abscess formation.

The course of acute gonococcal inflammation of the urethra may be roughly divided into (1) a period of increase, which varies widely according to the treatment employed, and ranges in duration from one to two weeks; (2) a stationary period in which the inflammatory changes may show little improvement; its duration is from one to two weeks, contingent upon the treatment, the development of immunity, and the complications that arise; (3) the period of decline, which lasts for one or more weeks, is characterized by the presence of very few gonococci in only a small amount of urethral discharge, which perhaps may be seen in the early morning only. The duration of this period is again dependent upon the treatment, but to a greater extent upon the protected foci and urethral strictures than upon immunity, which at this stage may be already sufficiently high to cause the clearing of the inflammatory changes except for focal infection; this period is subject to recurrence of the discharge with a marked increase in the number of gonococci. The urine nearly always shows shreds; the mucous membrane has changed from the cylindrical type of epithelial cells to the pavement variety which is more resistant to the invasion of gonococci.

Prognosis. The time required to cure a patient with acute gonorrhea varies with: (*a*) the promptness with which treatment is started; (*b*) the type of treatment employed; (*c*) the patient's tolerance to sulfanilamide; (*d*) and the occupation of the patient.

The promptest cures are obtained by the combined use of sulfanilamide and argyrol sealed in the anterior urethra (see Treatment of Acute Gonorrhea). This plan can only be employed when the patient reports for treatment within 2 days after the urethral discharge appears. After the infection has become well established uncertainties as to the time for eradication are greatly increased. They concern the tolerance and response to sulfanilamide, the development of complications and the existence of pocketed areas in which the micro-organisms may become entrenched. For resistant gonorrhea prompt cures may be effected about nine times out of ten by the combined use of sulfanilamide and hyperpyrexia.

The danger of infection being carried to the eyes by accidental transference is slight, but patients should be warned of the possibility and urged to exercise care in preventing such infection. Complications such as epididymitis and prostatitis are much less frequently seen in patients who are treated with sulfanilamide than in those who do not or cannot take it.

Acute posterior urethritis. There are wide variations in the subjective symptoms of posterior urethritis, and in some instances the attack is so mild that the invasion of this part of the urethra is not suspected; in others, the urination may be frequent and pain extremely severe. A posterior urethritis without a coincident prostatitis seems impossible; the prostatic enlargement may not be sufficient, however, to permit at once the diagnosis of acute prostatitis.

Etiology. Dissipation, sexual excitement, unusual physical exertion, and inappropriate and rough treatment are prone to cause the development of deep urethritis. Extension to the posterior urethra may occur, however, in well behaved and properly treated patients. Long motor trips seem particularly likely to cause invasion of the prostatic urethra; long train trips are harmful, but not to the same extent as are motor trips. Riding motor cycles, bicycles, and horses also tends to spread the infection from the anterior to the posterior urethra; the same may be said of exposure to cold, hard manual labor, violent exercise, excessive dancing, overzealous treatment, a small meatus, and obstructive lesions of the anterior urethra.

Symptoms. The patient notices first a slight increase in the frequency of urination; as the condition becomes worse, the frequency increases and the desire to void becomes urgent. Urination is painful while voiding and at the end of micturition. The patient may feel that the bladder is not completely emptied and his continued straining (tenesmus) may bring a few drops of blood. Desire to void is due to the turgesence and sensitiveness of the mucous membrane of the deep urethra and verumontanum. Frequency of urination is usually worse at night; the desire to void gradually becomes worse until, in extreme cases, there may be little peace during the day or night. Closing down of the sphincter muscles on the inflamed prostatic urethra may cause pain along the urethra, at the end of the penis, in the perineum, in the rectum, or in the hypogastrium. Palpation of the prostate, Cowper's glands and the vesicles is necessary from time to time to enable the physician to follow the progress of infection and to detect the formation of abscesses of the prostate when such changes occur. Retention of the urine does not result from posterior urethritis until inflammation has become well established in the prostate. A Cowper's gland may become inflamed without specific symptoms directing attention to it.

Constitutional symptoms. The patient with acute posterior urethritis often shows constitutional symptoms such as chills, fever, loss of appetite, constipation, physical weakness, pallor, and loss of weight.

Diagnosis. The diagnosis of acute posterior urethritis is made from the history of acute anterior urethritis, followed by frequent, painful urination, tenesmus, terminal hematuria, and cloudiness in all glasses of urine. Definite enlargement and tenderness of the prostate will nearly always develop with symptoms of acute prostatitis; these differ slightly, if at all, from those caused by severe inflammation of the deep urethra. Constitutional symptoms, though, are more marked and the leucocyte count is higher in prostatitis.

Prognosis. The early recognition of deep urethritis can be anticipated to some extent by cloudy urine in the last glasses, and the patient should be warned regarding extreme care as to exercise, treatment, good behavior, and abundant rest. The duration of acute posterior urethritis is from one to two weeks, varying with the extent and severity of coincident prostatitis, prostatic abscesses, seminal vesiculitis, cowperitis, and urethral strictures.

Chronic posterior urethritis. Chronic deep urethritis should not be regarded as a disease in itself so much as a symptom complicating inflammation of the adjacent glandular structures. A study of the deep urethra necessarily includes an investigation of the prostate, utricle, verumontanum, diverticula, and seminal vesicles, as well as of the pathologic changes of the anterior urethra.

Chronic deep urethritis is usually associated with, (*a*) mild frequency in urination; (*b*) slight pain and discomfort before, during, and after urination; (*c*) disturbances of the sexual function; and (*d*) recurrent urethral discharges. It is more important to diagnose the complications associated with chronic deep urethritis than it is to recognize the urethritis itself, which, as above stated, is usually essentially a symptom, not a disease *per se*.

Pathology. Associated with chronic gonorrhea there is nearly always a coincident prostatitis or vesiculitis and, less frequently, a chronic cowperitis; occasionally there may be papillary growths or granulating areas, especially around the inflamed crypts. Localized inflammation is particularly likely to occur at the points where there was trauma incident to painful erections during the acute period; when the infiltrated mucosa and submucous tissues are pulled upon, damaged, and subsequently healed by scar tissue, urethral strictures result. The glands of Littré may be felt as small shot or beadlike masses along the urethra, or they may harbor gonococci and a small amount of pus without being palpable. Briefly stated, it may be said that acute urethral inflammation is characterized by a generalized urethritis, which gradually merges into the chronic form with the dominance of the crypts or focalized infection, and strictures or potential strictures. Oberländer classified the lesion chronic urethritis into soft and hard infiltrations. The former is merely the forerunner of a later connective tissue change. Organisms other than gonococci are usually absent in acute gonorrhea, or at least they are present only in small numbers; they probably play an unimportant part and may be disregarded. This statement does not hold true, however, for chronic urethritis.

Chronic gonorrheal inflammation gradually merges into an inflammatory process continued by other organisms or factors, and to determine with certainty the precise time at which this change occurs is difficult.

Urinary findings in chronic deep urethritis. There may be pus and shreds in all glasses or only in the first. Having the last glass clear does not eliminate the possibility of inflammation of the deep urethra, as can be proved by irrigating the anterior urethra before the patient empties his bladder and having him void into several glasses; pus and shreds then in the first glass indicate deep urethritis.

Differential diagnosis. It is impossible intelligently to treat chronic gonorrheal urethritis without knowing to what extent the prostate gland, seminal vesicles, and Cowper's glands are involved, and whether there are urethral strictures.

The frequent urination caused by bladder tuberculosis may present certain symptoms which simulate deep urethritis; the history of the affection, a careful examination, and properly stained smears will, usually, make the diagnosis clear. It should be remembered, though, that these diseases may coexist.

Seminal vesiculitis is suspected as a factor in perpetuating urethritis when there has been an acute epididymitis and especially when inflammation of the epididymitis has been recurrent. The palpating finger in the rectum may detect enlarged seminal vesicles or they may appear normal, even when infected. The differential diagnosis of seminal vesiculitis may be facilitated by a study of condom specimens of semen. Smears should be stained and the number of pus cells in the fields compared with the number found in a smear of prostatic secretion, the specimen having been made of about the same thickness at a previous examination and preserved for comparison. The patient should be instructed to void just before coitus to wash out urethral shreds and pus.

THE TREATMENT OF GONOCOCCAL URETHRITIS

Prophylactic measures. The results of the prophylactic treatment used in the army and navy showed that, when promptly and properly used, it lessened the danger of contracting venereal diseases. This method of prophylaxis consisted of: (*a*) thorough washing; (*b*) urinating; (*c*) the injection of a 2 per cent. solution of protargol into the anterior urethra and holding it for about five minutes, and (*d*) rubbing well a 30 per cent. calomel ointment over the penis, subpreputial space, glans penis, perifrenal areas, pubic region and anterior part of the scrotum.

A satisfactory measure in preventing gonorrhea is afforded by sealing argyrol, or some such mild colloidal silver solution, in the anterior urethra with collodion and leaving it in the urethra for 4 or 5 hours. This method has the advantage of being effective in preventing gonococcal infections when employed as late as three days after exposure. One treatment should be administered daily for each 24 hours or fraction thereof of the time which has elapsed since exposure. That is, one treatment should be given for each day of delay in taking the prophylactic treatment. If so employed this plan is most dependable.

Treatment of acute anterior gonorrhea. If the infection is of recent origin, with the usual incubation period, and if the discharge has not been present for more than 2 days, a high percentage of prompt cures may be obtained by the combined use of sulfanilamide orally and a 5 per cent. solution of argyrol sealed in the anterior urethra once a day for 4 days. The sulfanilamide should be administered in doses of 20 grains each, four times a day for the first 2 days and in 15 grains four times daily for the next 2 days. The 5 per cent. solution of argyrol should be freshly prepared each day. The patient voids, the meatus is washed, 1½ cc. of the solution is injected into the urethra and retained with clamps. Collodion is applied with a camel's-hair brush to the meatus and glans penis. The most satisfactory clamps are those used in laboratories for holding test tubes; small rubber tubing is slipped over the part which comes in contact with the penis. Two are employed to hold the penis upright while the collodion dries.

When the collodion has dried the clamps are removed. If there is no leakage, a condom is placed over the penis and the patient is instructed to postpone voiding for 4 hours if possible. Straining efforts which might cause the solution to escape should be avoided. The U.S.P. Collodion, not the flexible, should be used. The treatment is administered once a day for 4 days. During this time, of course, the sulfanilamide is continued as mentioned above. Ballenger, Elder, McDonald and Coleman report more than 200 consecutive early cases of gonorrhea with only 4 per cent. of failures to obtain prompt cures by this combined treatment.

Internal medication. In the modern treatment of gonorrhea, little emphasis is placed upon the use of the balsamic remedies, which were formerly much in vogue. When these preparations are administered in quantities sufficient to exhibit their curative effect, disadvantages are likely to arise. The most evident disturbance, usually, is gastric; eructation of the balsamic remedies and gastric annoyances, such as indigestion and nausea, often cause loss of appetite, resulting in insufficient nourishment being taken. The advantages appear to be so nearly equalled by the disadvantages that the net gain seems not to justify the routine employment of balsamics, except for certain specific complications such as frequency of urination and discomfort associated with deep urethritis.

Hexamethylamine, urotropin, while of value in renal and bladder infections, seems of little or no benefit in gonorrhea. Urotropin has a tendency, at times, to irritate the neck of the bladder, producing symptoms and frequency of urination not unlike those caused by deep urethritis and, when employed, the patient should be directed that it be taken for 4 or 5 days, then left off for 3 days; after the few days' rest, the urotropin should be resumed and continued with the periods of rest. The dosage should be gram 1 to 2 (grains 15 to 30) three times a day, dissolved in a glass of water.

Sulfanilamide. *History.* The dramatic response of gonococcal infection to the oral administration of sulfanilamide made the year 1937 a notable one in the treatment of gonorrhea. To Dees and Colston belong the credit for directing attention to the value of this drug in the treatment of gonococcal infections.

Domagk, in 1935, had shown that prontosil (sulfanilamide) had a marked bacteriostatic prophylactic action against hemolytic streptococcic infection in mice. Soon he demonstrated its value in the treatment of such infection in man. Domagk's observations were confirmed by others. In a short time numerous observers noted that many other types of infection also responded to sulfanilamide therapy.

Following the report of Dees and Colston the use of sulfanilamide was taken up with great enthusiasm. The toxic effect of the drug and its failures in a very considerable percentage of patients treated with it, even when it was taken in adequate doses, soon caused the enthusiasm to wane and its use to become more rational.

Mode of action. The therapeutic results of sulfanilamide are strangely inconsistent. It is more effective in *vivo* than in *vitro*. It is also more effective in some patients than in others with the same infection, same dosage and same blood concentration.

Judged by the enormous number of papers published upon the experimental and clinical studies of sulfanilamide, it seems that heretofore no other drug has ever been given such immediate and intensive study. Yet even after all of this study the exact mechanism by which its chemotherapeutic action is effected remains unsettled. Its beneficial results come probably not from a single action but rather from a combination of its effects. Undoubtedly, too, these effects vary with different micro-organisms as well as with different patients.

The *bacteriostatic* action of sulfanilamide for many micro-organisms is generally conceded. Its *bacteriocidal* action against the gonococcus, at times is evident; at others it seems to be only bacteriostatic; while in still others its beneficial effects appear to be dependent upon assistance from the *defensive mechanism* of the host. *Phagocytosis* undoubtedly plays a part in the fight but only a supplementary part.

It is quite conceivable that micro-organisms sickened or retarded in growth by sulfanilamide produce less toxic material and in consequence may undergo phagocytosis more readily than they do when growing luxuriantly.

It also appears that man's defensive mechanism functions better when the growth of bacteria is inhibited.

Regardless, however, of the manner in which it works, sulfanilamide is a potent agent in the treatment of gonorrhea and other infections. Even when its curative value is slow it has a decided tendency to limit the extension of gonococci into new areas. This is especially true of areas having a free circulation of blood and lymph. This is strikingly shown clinically in a great reduction in the percentage of the complications formerly encountered in the treatment of gonorrhea.

Dosage. The amount of sulfanilamide desired and the amount tolerated vary widely, so widely that specific doses cannot be determined in advance. Much depends upon the duration of the infection and the plan of treatment employed to supplement sulfanilamide, the patient's age, weight, physical condition, renal function, occupation and availability for frequent observation. It is generally desirable to start with as large doses as circumstances seem to warrant, perhaps 80 grains a day, and within two days to reduce this amount by about one fourth or one third. This dose can be reduced still further in about three days if clinical improvement is satisfactory.

The objective naturally sought is control and extermination of the infection as early as possible. Yet when complications exist, or when circumstances prevent close observation, and when it seems likely that treatment may have to be protracted, it is better to start with doses of sulfanilamide that may be continued for a considerable period of time rather than to run the risk of producing toxic reactions and early intolerance to the drug. Small doses, on the other hand, may not produce the beneficial effect of sulfanilamide ordinarily likely to follow its use in adequate doses. Patients who are hospitalized and those who may be closely watched may be given larger doses than those in whom circumstances prevent frequent examinations to ascertain if dangerous toxic reactions are arising.

The doses of sulfanilamide should be spread fairly evenly throughout the 24 hours so as to obtain an even concentration in the blood stream. Sulfanilamide tends to produce an acidosis; to prevent this bicarbonate of soda should be given in an amount sufficient to render the urine neutral or alkaline in reaction.

Excretion. Sulfanilamide is excreted almost entirely by the kidneys in both the *free* and *conjugated* forms. Formerly in the treatment of gonorrhea it was thought desirable to have the patient drink freely of liquids. With sulfanilamide therapy in genito-urinary infections it is now preferable to keep the intake of liquids low in order to obtain a high concentration in the urine. In gonorrheal urethritis the patient should be advised to void frequently, at least every hour during the day, so as to obtain the maximum benefit from the frequent flushing of the urethra with urine laden with sulfanilamide. As might be expected patients with poor kidney function excrete sulfanilamide slowly. In consequence they obtain a high blood concentration with relatively small doses and develop toxic reactions early.

Toxic reactions. Few drugs produce so wide a variety of reactions as does sulfanilamide. Symptoms such as headache, loss of appetite, nausea, malaise, dizziness and mild cyanosis and mental dullness, are of such common occurrence they hardly deserve to be called toxic reactions. At least the drug need not be discontinued because of such disturbances.

More serious are the various skin eruptions, edema, paræsthesias, sulphemoglobinemia, methemoglobinemia and febrile reactions.

Still more serious reactions are hemolytic anemia, agranulocytosis and (rarely) optic neuritis.

Saline purgatives, especially magnesium sulphate, should be forbidden to patients who are taking sulfanilamide because of the possibility of its inducing sulphemoglobinemia. Upon the development of serious reactions sulfanilamide should be discontinued at once and fluids forced to hasten its elimination. At times, after skin eruptions have subsided sulfanilamide may be resumed cautiously. Occasionally transfusions are required for those who develop hemolytic anemia. Granulocytopenia is the most dangerous toxic result which follows the use of sulfanilamide and when well established, it usually is not responsive to treatment. Serious toxic reactions may arise from even moderate doses of sulfanilamide. Careful clinical observation and blood studies from time to time, therefore, are necessary so that these toxic manifestations may be noted at their inception.

Supplementary measures. Opinions as to the extent the routine measures ordinarily used in the treatment of gonorrhea should be employed to supplement sulfanilamide vary widely among those competent to express opinions as to the proper management of this disease. The supplementary treatment should vary also with the duration of the infection and with existing complications.

Generally speaking, it is desirable to use all reasonable assisting measures, general as well as local. Sulfanilamide really should be employed as a valuable agent with which to assist rather than to supplant measures of recognized value. Some who have had very considerable experience in the treatment of gonorrhea with sulfanilamide advise that its employment be postponed until about two weeks after the appearance of the urethral discharge. The object of this delay in its use is to permit the natural defensive reactions on the part of the host to develop; and it is true that when such defensive reactions have arisen and are reinforced with sulfanilamide brilliant therapeutic response often is seen. Against this argument is the fact that such delay often permits the development of troublesome complications. Moreover, the patient may think the plan to be quite unreasonable.

Personally we prefer the immediate use of sulfanilamide; this preference is very decided for the patients who come for treatment within the first 2 days after the discharge appears. In this particular group our results have been exceptionally good when a 5 per cent. solution of argyrol sealed in the urethra once a day for four days has been supplemented with 80 grains of sulfanilamide a day for the first two days, and 60 grains a day for the next two days. More than 200 patients have received this treatment with 96 per cent. of cures (see Technic, page 866). By no other plan of treatment have we been able to secure such consistently good results.

When the infection is well established, that is after the discharge has been present for more than 2 days, the usual routine measures of recognized value are instituted and sulfanilamide is begun. The treatment is continued until it appears that the patient is well of his infection.

Clinical improvement often far outruns the final eradication of the gonococci. The use of sulfanilamide has made the tests as to cure much more exacting than they were formerly. This is true both clinically and bacteriologically. The gonococcus not only changes its morphology but also its staining characteristics; culture tests have become of decided importance where an early statement concerning the presence or absence of the infection is needed.

Tests with stained smears as formerly used may be quite misleading unless the patient is observed over a considerable period of time after clinical signs of gonorrhea have disappeared and for a considerable time after sulfanilamide has been discontinued.

Resistant infections. With the use of sulfanilamide and the routine measures ordinarily employed in the treatment of well established gonorrhea there is a considerable number in whom the infection remains resistant. These failures clinically may be recognized as of two distinct types and may be placed in two groups: *group one* — those in whom the infection responds well to treatment but recurrences develop when treatment is discontinued;

group two — those in whom the infection fails to respond, the discharge continues and the urine remains cloudy with pus. It is clearly evident that these two types of failures are due to distinctly different causes. It is equally evident that success with further treatment is contingent upon early recognition of the chief retarding factors.

Failures in group one are due to infection in protected foci in which sulfanilamide and defensive antibodies do not circulate in sufficient concentration to eradicate the bacteria. Failures in group two appear to be due either to failure of the defensive mechanism of the host or to exceptional tolerance of the infecting micro-organism to sulfanilamide.

Being due to totally different causes failures in group one require entirely different treatment from those of group two.

Group one needs the application of local measures to the protecting pocket or the eradication of the "dead space" with its stagnant secretion which protects the gonococci from the maximal benefit of sulfanilamide.

Group two clearly needs something of a general character — something to reinforce the host's defensive mechanism, a better chemotherapeutic agent, or something to render the micro-organism vulnerable.

Treatment of group one. Among the potential protected foci or "dead spaces" which harbor gonococci the following may be mentioned: paraurethral crypts, periurethral follicles, areas at urethral strictures, prostatic pockets or abscesses and seminal vesicles distended with stagnant secretion. These protected foci should be considered and appropriately dealt with when treating resistant infection belonging to type one.

Lockwood has shown in a convincing manner that pus and necrotic tissue tend to protect the micro-organisms from the effects of sulfanilamide.

When failure seems to be impending because of protected foci or "dead spaces" which harbor infection, they should receive appropriate local measures. Abscesses should be drained; fistulas opened and treated with germicides; urethral strictures should be dilated, and, if the meatus is small, meatotomy should be done.

Treatment of group two. In this group, where the major response to sulfanilamide is lacking, discharge persisting and urine remaining cloudy, a rational explanation of the reasons for such failures is not so easily found as in group one.

The fault in such cases appears to be assignable to sulfanilamide, to the host, or to the strain of gonococci. The strain of the infecting micro-organism cannot be changed. A change, however, in the chemotherapeutic agent may be made, or accessory measures such as hyperpyrexia may be employed to activate the host's defensive mechanism.

Of the chemicals related to sulfanilamide, *sulfapyridine* may be taken as a type. Bacterial infection often will respond to one of the newer preparations, related to sulfanilamide, when it has failed to yield to sulfanilamide.

In case chemical agents fail hyperpyrexia is the most dependable supplementary agent.

Sulfapyridine. Among the numerous chemicals more or less closely related to sulfanilamide sulfapyridine seems quite promising. The dose usually effective in the treatment of gonorrhea is 45 grains a day. Occasionally larger doses may be administered. Although serious toxic reactions appear to occur less frequently than with sulfanilamide, minor toxic effects are common.

Cook and Sutton think that the administration of sulfapyridine in milk lessens the gastrointestinal distress frequently seen. The dose required in the treatment of gonorrhea does not have to be so large as that needed for the effective treatment of pneumonia.

The treatment of resistant gonorrhea, especially of the type designated as group two, should include an adequate course of sulfapyridine or some other chemical-cousin of sulfanilamide. By making such a change the treatment may be more effective because of the greater bactericidal value of the substitute or because the same toxic reactions produced by sulfanilamide may not arise from newer drugs, such as sulfapyridine or sodium sulfanil sulfanilamide.

If gonorrheal infection still persists, in spite of suitable local treatments and in spite of the substitution of chemicals such as sulfapyridine, hyperpyrexia then becomes the reinforcing measure of choice.

Chemothermotherapy. Sulfanilamide in combination with hyperpyrexia affords satisfactory means for treating patients in whom gonococcic infection *fails* to respond to the routine methods usually employed; it is also of value in the treatment of those who, for domestic or business reasons, have urgent need of prompt cure of gonorrhea. This plan also affords means for the prompt relief of painful complications such as epididymitis and prostatitis.

The exact manner in which fever mobilizes the body's defensive forces is not fully understood. A number of important factors appear to play a part such as: Increased velocity of the blood stream; dilatation of superficial blood vessels; increase in leucocytes; stimulation of reticulo-endothelial system and increased formation of antibodies and other immunizing bodies or substances.

Regardless of the explanation of the mechanism of sulfanilamide and of fever, there is no doubt as to the enhancement in the value of both of these agencies by their simultaneous employment.

Ample clinical evidence has shown that gonorrhea can be cured with decidedly less sulfanilamide and in a much shorter time when fever is used to reinforce it. Nor need fever be taken to a point so high nor maintained for so long a time when it is combined with the administration of sulfanilamide. In short, the disadvantages of both of these potent agencies are lessened and their advantages enhanced by their simultaneous use.

Ballenger, Elder and McDonald were the first to report upon the value of the combination of sulfanilamide and hyperpyrexia. Since their report in 1937, Cheetham and Roemer, Owens, Wright and Lewis and others have confirmed these observations. Wengatz, Boak and Carpenter have noted that the thermal death time of cultures of the gonococcus is reduced about 50 per cent. when a 1–10,000 concentration of sulfanilamide is present in the culture medium. Lewis administered large doses of sulfanilamide to rabbits and then heated them in air-conditioned cabinets. His experiments failed to show any contraindications to the combined use of these agencies. Experimenting with the capacity of rabbits to remove type one pneumococci from the blood following intravenous injection, Mellon states: " It is clear that the removal of injected pneumococci was effected more rapidly in the sulfanilamide rabbits than in the controls; more rapidly still in those given artificial fever; and with maximum rapidity in the rabbits given both fever and sulfanilamide ".

These experimental tests afford supportive evidence of the value of combining the administration of sulfanilamide with artificial fever. As has been already stated, this combination is not indicated, except for special reasons, until gonorrhea has failed to respond to sulfanilamide and its related compounds reinforced by appropriate routine treatment.

Hyperpyrexia treatments are administered every other day until three or four treatments are given. Sulfanilamide in doses of 60 to 80 grains daily is given two days before the artificial fever treatment and is continued during the intervals between them. It is desirable to have a fair degree of blood concentration of sulfanilamide at the time of the fever treatments, but preferably not a disturbing amount.

Selection of patients. No patient should be subjected to hyperpyrexia treatment who would not be regarded as a suitable subject for a major operation.

Preparation. The bowels should be emptied by purgative or enema the day before the treatment. Since the free flow of hydrochloric acid is checked by hyperpyrexia, food should not be taken immediately before or soon after the bouts of fever. Pantopon, one-third of a grain, by hypodermic should be given as the fever begins to rise. Stimulants are rarely needed in the combined treatments because of the moderate temperature required. Provisions for prompt cooling of the patient and an adequate supply of oxygen 95 per cent. and carbon dioxide 5 per cent. should be available for inhalation in case of difficult breathing or cyanosis.

Attention needed. Since there is a considerable loss of sodium chloride through excessive sweating, this salt should be administered freely during the fever treatment. The technician in charge should be alert, well informed, and constantly at hand. The temperature, pulse and respiration should be taken every ten or fifteen minutes. In our own work a pulse rate of 140 is regarded as a warning and, when reached, further heating is not given. Hyperpyrexia cabinets should be provided with means for quickly cooling the patient without disturbing the set-up. A restless patient is easily reassured by a short refreshing recess, and is then willing to resume the fever-producing measures.

An effort is made to obtain a rectal temperature of 104½ or 105½ degrees (oral 103 or 104) for three or four hours. This effort, however, is conditioned at all times by the manner in which the treatment is being tolerated by the patient. After the treatment is over the patient is placed in bed for two to three hours or longer, as required.

Unless contraindicated, the treatments should be repeated every other day until three or four have been administered. More should be given if the desired temperature has not been reached and maintained or if the infection has not been exterminated.

Results. Urethral discharge usually disappears in less than 24 hours, and the urine becomes clear, usually within 24 to 48 hours. Cessation of the pain from epididymitis and prostatitis is noted before the patient gets out of the cabinet. The swelling of the epididymis and of the acutely inflamed prostate disappears gradually and may require 5 to 7 days or longer.

Except for patients with obviously hindering factors, such as foci of infection protected in " dead spaces ", 90 per cent. of those receiving the combined treatment with sulfanilamide and hyperpyrexia may be cured with three or four treatments. Recurrences develop in those uncured as early as two days and as late as three weeks after the treatment is discontinued.

By preliminary elimination of protected foci the percentage of cures from three or four bouts of fever is increased. In fact, not infrequently attention to these details results in cure without the hyperpyrexia treatment. A surprisingly slight rise of temperature at times is effective. For instance, prompt improvement may follow when the rectal temperature does not exceed 103½ degrees, and four of these mild treatments may result in cures. Sometimes the difference between failure and success is very slight. It is like an automobile with a motor not quite powerful enough to reach the top of a hill. With a slight amount of pushing it may be taken over the steepest part and then proceed satisfactorily. Hyperpyrexia seems to give such a push to stalled immunizing response to sulfanilamide.

Diet in treatment of gonorrhea. The diet plays a comparatively unimportant part in the treatment of gonorrhea except to assist in controlling the reaction of the urine in carrying out the plan being followed to obtain diluted alkaline urine or concentrated acid urine. In either case the patient should refrain from highly seasoned food, peppers, mustard, pickles, et cetera.

Alcoholic and carbonated drinks are harmful.

Treatment with vaccines. The employment of gonococcic vaccines proves disappointing in the treatment of urethritis; it is not, however, without some value in certain of the complications which arise. Whether or not a patient will be benefited by vaccines cannot be determined in advance.

Dosage. The initial dose of gonococcic vaccine may be from 10 to 20 million organisms. The time and number of the organisms for the next treatment depend upon the degree and duration of the preceding reaction. As a rule, another injection should not be given until the reaction to the preceding one has subsided fairly well; this requires from 3 to 6 days. The immunity gradually acquired renders subsequent reactions more mild. In the course of time, doses up to several hundred million organisms may be administered.

Sites for injection of vaccines. The vaccines are usually administered subcutaneously in the deltoid or gluteal region. The results seem the same regardless of the site, and the preference of the patient may be followed. The injections are more painful if made in the muscle or in the skin than if given subcutaneously.

Intravenous injections for gonorrhea. A number of remedies have been tried intravenously in urethral gonococcal infections but without favorable results, except occasionally. Among the preparations which have been used are colloidal silver salts, mercurochrome, acriflavine, gentian violet and mercurophen. Complications such as acute epididymitis and acute prostatitis appear, at times, to have been benefited by intravenous medication, but the results in urethritis have been disappointing.

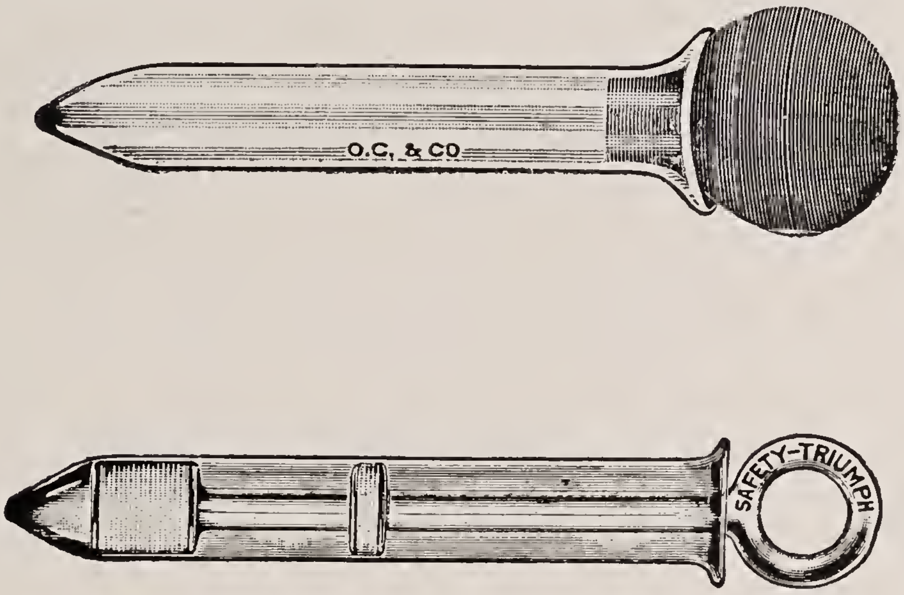

FIG. 12. Urethral syringes showing correct type of nozzles.

Urethral injections and irrigations. There are many factors to be considered in determining the time to begin local or direct treatment of the inflamed urethra. Experienced and capable genito-urinary surgeons differ in their opinions concerning the question; some think it better to allow the acute symptoms to subside before beginning local treatment, while others apply the local measures from the first. The majority employ, with certain reservations, the latter method, though hard-and-fast rules cannot be laid down. Patients, however, with even hyperacute affections, having the meatus much swollen and tender, a profuse creamy discharge and perhaps edema of the foreskin, often may be given mild injections and very gentle low-pressure irrigations of the anterior urethra with benefit. By starting treatment early the intensity of the inflammation is sufficiently controlled to lessen the severity of the painful erections, thereby reducing somewhat the danger of subsequent strictures from the injuries caused by stretching the infiltrated, inelastic urethra. On the other hand, immunity increases largely in proportion to the intensity of the infection and certain advantages subsequently accrue therefrom.

For the moderately acute or subacute conditions the consensus of opinion is that mild local treatments are never contraindicated and may be given from the start. Regardless of the stage of acute gonorrhea, the local treatment should be with soothing rather than irritating agents. Nearly all of the mild silver salts, weak solutions of potassium permanganate, acriflavine and such germicides will inhibit the growth of, or kill gonococci with which they are brought into contact. The injections of strong solutions of silver nitrate may cause strictures by a subsequent deposit of scar tissue. The patient should be impressed with the fact that appropriate diet, hygiene, hot baths, good behavior, and time, supplemented with attention to focal glandular infections and dilatation of urethral strictures, if present, are all factors of importance.

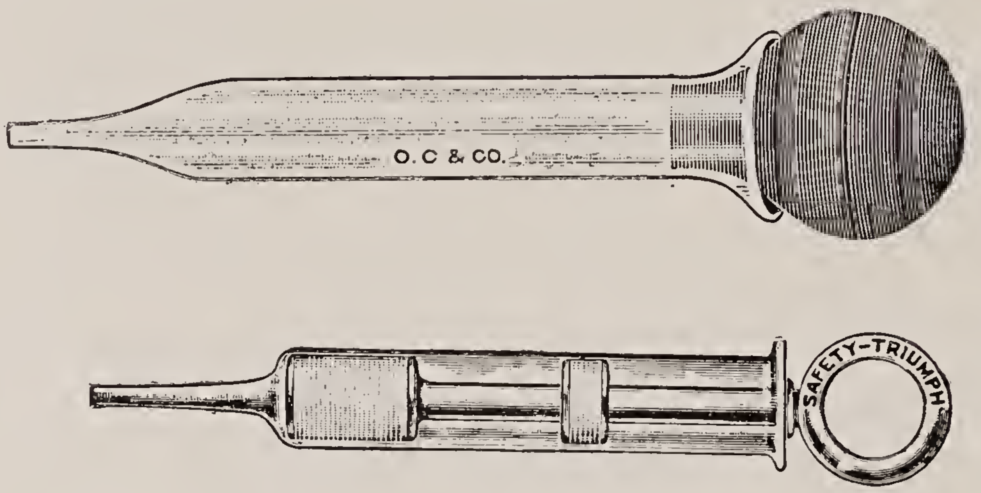

FIG. 13. Syringes showing incorrect type of nozzles for urethral injections.

Urethral injections. The so-called "hand injections" of the urethra by the patient himself are made with syringes of two types: those with pistons and those with rubber bulbs. The latter are preferred. The size should be from 10 to 15 cc. The syringes with small nozzles that enter the urethra should not be used. The injections are employed to supplement, not to supplant, the irrigations and other remedial measures. The technic of making the injection is as follows: The patient, having urinated, retracts the foreskin, and washes with a pledget of cotton the subpreputial area. The air should be expelled if the piston syringe is used; if a rubber bulb type is used, the penis is held upright so that the air will remain in the upper part of the syringe. With the glans penis between the forefinger and thumb of one hand and the syringe in the other, the nozzle is inserted within the meatus and the fluid is gently injected until the desired amount has been carried into the urethra. The meatus is then pressed so as to prevent the escape of the solution, which is held in the urethra for 2 to 10 minutes according to the acuteness of the inflammation and the strength of the solution. There may be a feeling of warmth or stinging, but there should not be a definite burning. At first, the injection should be administered by the patient 3 or 4 times a day; toward the end of the treatment the frequency should be reduced to once or twice daily.

Solutions to employ for urethral injections. There are numerous more or less adequate remedies, any one of which, if supplemented with the other necessary routine measures, will afford satisfactory results in the majority of instances. Sometimes favorite agents for injections seem unduly slow in controlling the discharge and inflammation; in such instances it is advisable to make a change. If mild silver salts are being used, it would be well to substitute acriflavine or some such germicidal dye, or vice versa.

Silver salts. Silver in nearly every form gives off germicidal ions or electrons. If a silver wire be placed on an infected agar plate it will be seen within a few days that there is no growth or micro-organisms in the area immediately around the wire. The enormously great subdivision of the masses of the insoluble silver salts, when in a colloidal state, results in a vast increase in the surface from which germicidal ions and electrons are given off, with a consequent increase in the bactericidal action. All of the mild silver preparations are in this colloidal state, whether they are brownish ones, if the silver is combined with protein material; or the white, if combined with chlorine; or the light yellow, if combined with iodine. When observed with a high-power lens and dark field illumination, all of the preparations in a colloidal state show myriads of white, actively motile, minute masses. They are constantly striking against each other, and show a tendency to coalesce; by this process the minute masses gradually increase in size and decrease in number until their combined surfaces have greatly decreased.

Selection of the preparation to be used as an injection is not of prime importance, as there are many of sufficient germicidal activity, and non-irritating, to permit a wide latitude in the choice. Non-staining agents can be used with greater freedom and, therefore, with more regularity than those which require care to prevent telltale stains. Among the silver preparations which may be used in a 5 per cent. solution are: neosilvol (colloidal silver iodide), lunosol (colloidal silver chloride), argyrol, silvol, argentide, solargentamin, reargon, and many others. Protargol is a good germicide and is a somewhat irritating agent, but may be used in a $\frac{1}{4}$ to 1 per cent. solution. Potassium permanganate affords an inexpensive but useful urethral injection; while the strength employed as an irrigation varies from 1:10,000 to 1:6,000 a more concentrated solution may be used for hand injection; 1:1,000 is not too strong. Zinc permanganate, 1:2,000 to 1:1,000, is also of value, at times. Zinc sulphate, 1:500 to 1:100, has definite astringent qualities and is used occasionally in subsiding acute gonorrhœa and in acute urethritis. Silver nitrate, 1:1,000, to 1:250, is sometimes advocated in subsiding acute and chronic urethritis where its stimulating and irritating astringent action is desired, but not infrequently a free discharge again is started; stronger solutions are employed usually only as deep instillations or applications. Copper sulphate may be used in the same strength for its astringent effect.

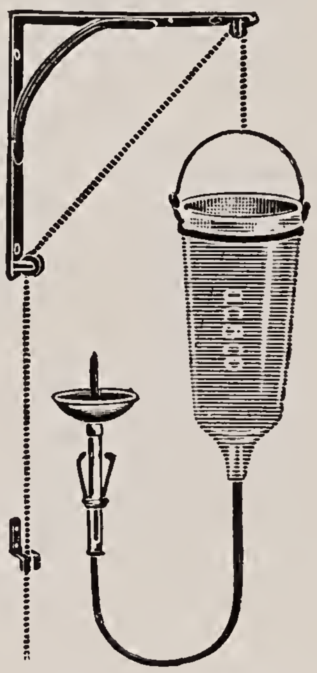

FIG. 14. Valentine irrigator.

Irrigations of the urethra. This method of local treatment of the urethra differs from injections in that a larger quantity of a weaker solution is used for the irrigation. There are two ways of giving urethral irrigations: (*a*) by hydrostatic pressure, and (*b*) by the syringe method. During the treatment the patient may stand, sit, or recline according to the preference of the surgeon. Irrigations may be limited to the anterior urethra by using little pressure, or the solution may be " coaxed " through the urethral sphincters into the bladder. By means of a large syringe of the piston or bulb type, solutions may be injected as previously described under Urethral Injections, from which this method differs only in the size of the syringe and amount of the solution used.

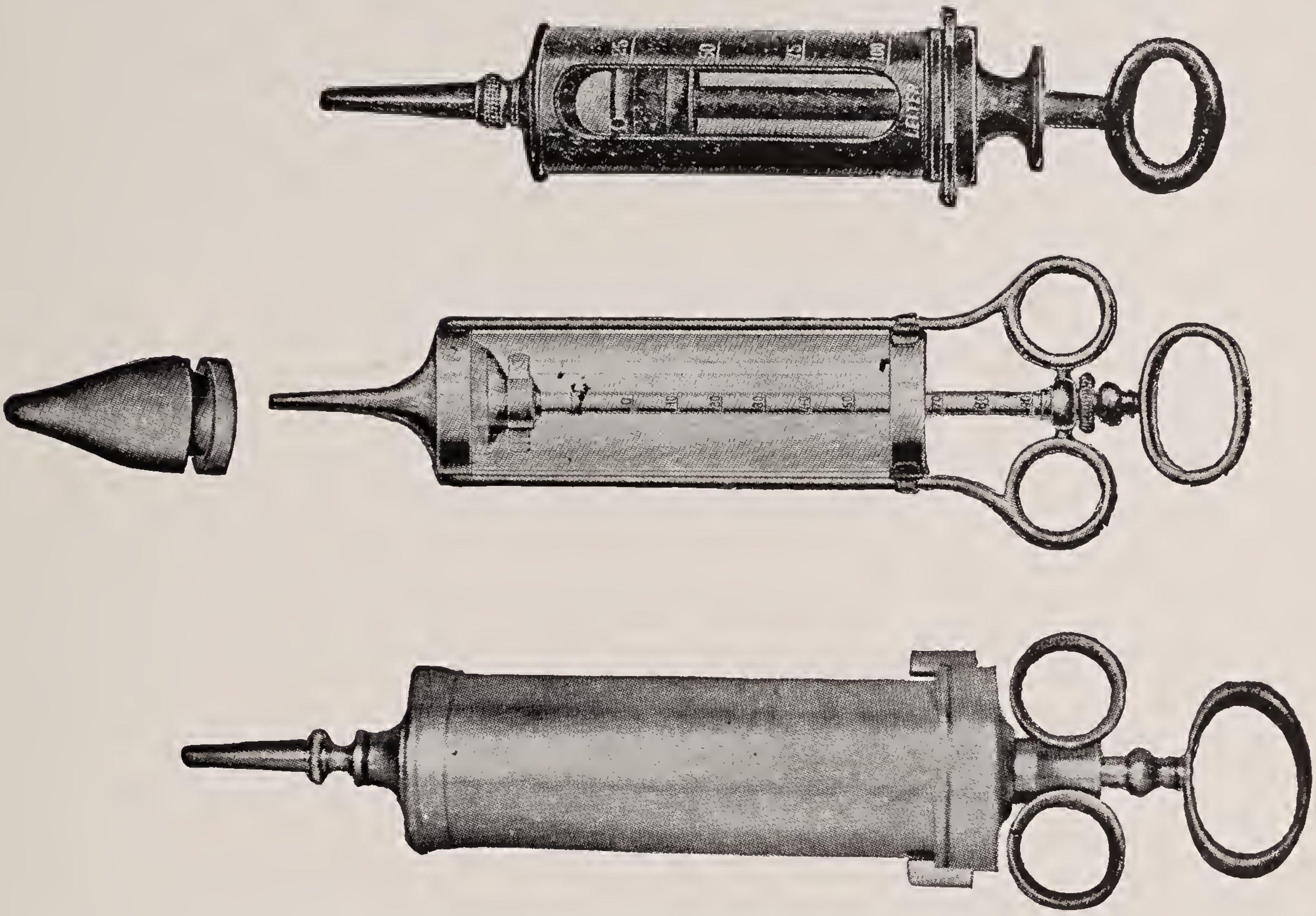

Fig. 15. Hard rubber, glass, all-metal syringes of the Janet type, and rubber syringe tip.

Solutions for irrigations. Potassium permanaganate, 1:10,000 to 1:4,000, is the solution most frequently used in urethral irrigations in acute gonorrhea. Formerly, stronger solutions were advocated by Janet and his followers, but soon it was observed that the weaker solutions were better, especially if the irrigations included the deep urethra and bladder. In a considerable percentage of patients, if even a weak solution of potassium permanganate is

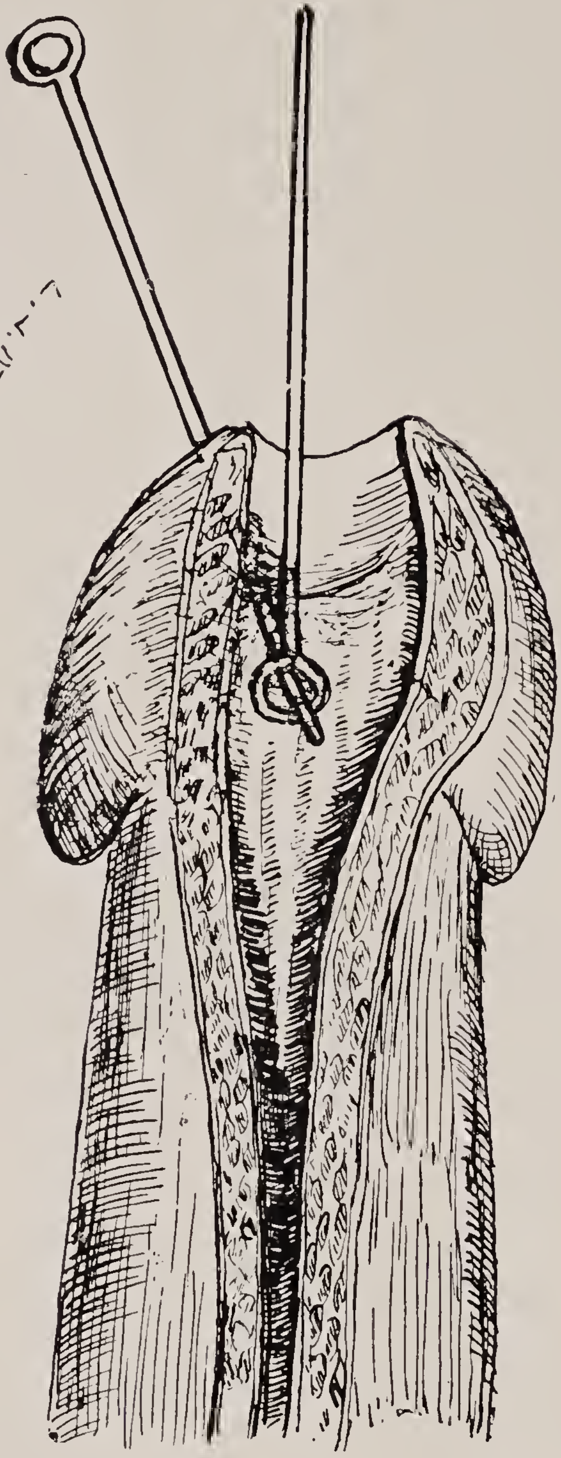

FIG. 16. Small probe passing through paraurethral duct and perforating urethral mucosa. Loop passed over end of the probe in the urethra to permit traction while anesthetizing and incising tissue between the duct and urethra.

allowed to remain in the bladder for 20 minutes or longer, definite irritation is produced. A satisfactory substitute in such instances is acriflavine, 1:10,000 to 1:6,000.

Silver nitrate in 1:10,000 to 1:5,000 solution is a valuable astringent germicide, but its employment should be restricted to subsiding acute conditions and chronic urethritis; by gradual increase, stronger solutions may at times be employed with advantage.

Mercurochrome solutions, while of value in certain bladder inflammations and pyelitis, give somewhat disappointing results in

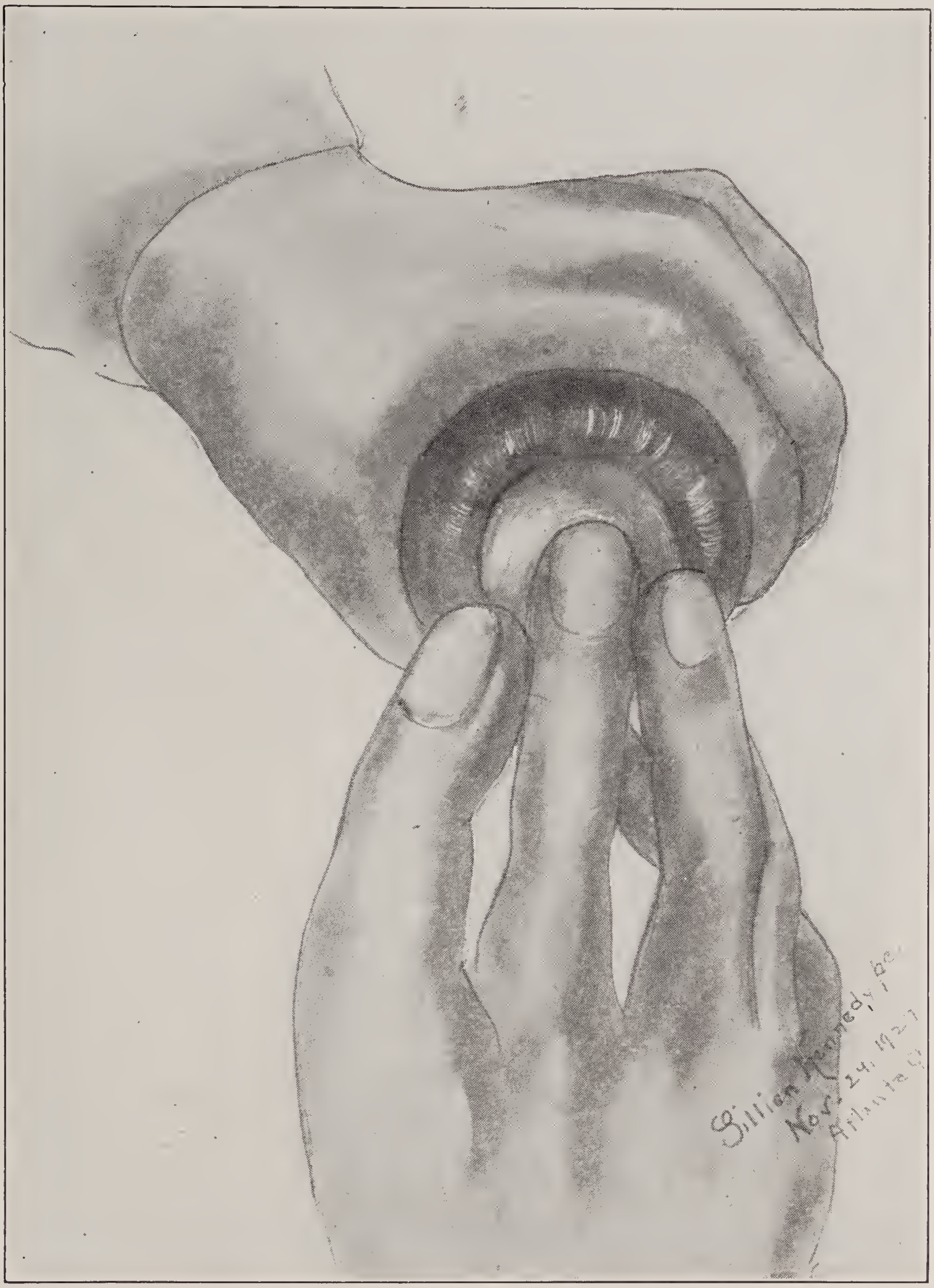

FIG. 17. Showing the wrong method of reducing paraphimosis. The edema should be decreased by manual pressure first. A towel should be placed around the swollen part and the patient should compress it for about 30 minutes, after which it is not unlikely that the foreskin can be brought over the glans penis without difficulty.

the treatment of acute gonorrhea, both as an irrigation and as an injection. It is, however, of value in the subacute or chronic inflammations and may be used in a ½ of one per cent. solution.

Deep irrigations may be given when the urine shows shreds and pus, after the anterior urethra has been washed free from these inflammatory products. Most patients readily admit the solution into the bladder; for a few it seems impossible; with the majority, a slight increase in the intraurethral pressure causes the solution to pass the external sphincter and enter the bladder, especially when the patient makes an effort as if voiding, or breathes deeply. It is better to limit the irrigation to the anterior urethra than to employ high pressure to cause the solution to pass a sphincter which will not relax or one in which undue straining results from the attempt. The irrigations are administered once daily until the discharge ceases and the cloudiness in the urine disappears; the treatments are then given every other day until the shreds disappear. This rule is subject to wide variations. Instrumental irrigations are not recommended.

Treatment of infection of paraurethral glands. The small openings of the paraurethral glands at the meatus prevent adequate drainage or medication. The channel or pocket should be opened into the urethra by incision of the intervening tissue, which is facilitated if the small wires used to keep open 18 or 20 gauge needles are employed as probes. One of these small wires should be passed as far as possible through the tract, and the mucosa is then pierced so that the probe enters the lumen of the urethra for 1 or 2 cm.; if the tract is deep, the urethroscope may be required to determine the extent to which the probe should be inserted. The loop end of a wire or hairpin is introduced into the urethra and manipulated so as to engage the probe wire protruding from the mucous membrane. The part to be incised may then be drawn upward and held in position while being infiltrated with novocaine and incised. The incision should not be completed at the lower part until Monsell's solution (an aqueous solution of ferric sulphate) is applied to the surface already cut; incision of the lowest part last, permits the application of the Monsell's solution to prevent bleeding and subsequent pain. By this procedure the tract is opened into the urethra and the focus of infection is partly or completely eradicated.

Gonorrheal periurethral abscesses. Periurethral abscesses sometimes rupture into the urethra, but more frequently point externally and may be opened and drained through a small incision. Healing is usually satisfactory, but occasionally a fistula follows and requires excision. For details see the section devoted to Urethral Abscesses.

Treatment of acute posterior urethritis. The advent of sulfanilamide has greatly lessened the frequency of posterior urethritis. If this remedy can be taken in adequate doses no special additional treatment is needed when the inflammation has reached this area. When sulfanilamide cannot be taken, balsamics, pyridium, hot baths and rest afford a moderate degree of relief; complications, such as epididymitis, are then not unlikely and the patient should be warned accordingly.

If retention of urine occurs and persists, after the usual remedies have been employed, novocaine in a 1 per cent. solution should be gently injected into the urethra and a catheter passed. After emptying the bladder a solution of a colloidal silver preparation, such as neosilvol or argyrol, should be injected into the bladder and also along the urethra as the catheter is withdrawn.

Diathermy, fulguration and electrodes in the treatment of gonococcal urethritis. These agents have been tried, from time to time, but each has its limitations and disadvantages. Electrolysis was employed to a limited extent many years ago with the idea of causing germicidal chemicals to be carried through the mucosa into the protected foci. While occasional results were encouraging, this plan of treatment has been of little practical value. Fulgurating foci of infection in the glands of Littré and anomalous tracts connected with the urethra may afford effective means of destroying foci in the urethra, but frequently infection co-exists in the prostate and seminal vesicles and continues or sometimes is made worse by the fulguration of the urethral tract. Care, therefore, is required in the selection of patients for this treatment; and in the majority of instances by the time proper attention has been directed to the prostate, to the seminal vesicles and to the dilatation of urethral strictures, the cryptic infection will have been eradicated. If, however, such is not the case, urethroscopic examination becomes indicated and fulguration of the glands of Littré, to destroy the nidus of infection, may be followed by a prompt cure — only, however, when all of the foci are eradicated. For this work an electrode should be employed which slides in the insulation so that the exposed part may reach all of the tract. When the current is applied the overlying mucosa is turned white and sloughs away later, leaving a smooth area where there was a pocket. Each gland of Littré should be destroyed, as well as other anomalous tracts, in so far as it is feasible. For the larger glandular openings and diverticula in the prostatic urethra, one or more segments are destroyed, when possible, so as to make the openings large to permit better drainage and better medication by the injections and irrigations.

While strictures are likely to arise at these infected foci, the tendency is not increased by carefully fulgurating the diseased area because it involves only part of the circumference of the urethra.

Within four or five days there is likely to be a slight bloody discharge, especially after erections. This results from separating of the slough and soon subsides without treatment. An adequate supply of electrodes of different sizes and types, as well as good water, dilating urethroscope and a high frequency machine with a foot switch are necessary for satisfactory work.

Treatment of chronic urethritis. General considerations. The major part of what has been said concerning the management of acute urethritis, especially in its subsiding stage, applies in the treatment of chronic inflammation of the urethra. While the condition found in the former is essentially diffuse, in the latter it is localized. Change from the acute stage to the chronic comes about very gradually, and associated with this process is the localization of organisms in infected areas. Later, if the infection still persists, and the existence of urethral obstruction seems likely, the urethra may be gently explored with bulbs and sounds. If strictures are found, they should be cautiously and gradually dilated. Local measures should be administered between dilatations to control the reactions they cause. Still later, if infection and inflammatory changes continue, the urethroscope should be employed to diagnose and treat the focal areas in the urethra. The prostate gland, seminal vesicles, and Cowper's glands should receive adequate attention, and the usual local, hygienic, and supportive measures should be employed.

A narrowing of the meatus, congenital or acquired, tends to keep up a chronic urethritis and is often associated with congenital strictures of the urethra. A meatus smaller than a 26 F. should be enlarged if the urethral or urinary symptoms persist. This should not be done, however, until the immunity is fairly well established and the urethral symptoms are under control.

Silver nitrate, in a ½ to 2 per cent. solution, is not infrequently used as an instillation. The weak solutions should be used at first and the strength gradually increased as reactions permit.

Chronic deep urethritis, as the acute, should be regarded not as a disease itself but as a symptom of associated pathologic lesions, such as prostatitis, seminal vesiculitis, cowperitis, diverticulitis, and infection of the utricle. After adequate efforts have been made with the measures usually employed for infections of the urethra and adnexa, and after the dilatation of strictures, an examination of the deep urethra with a urethroscope should be made. This investigation may reveal: (*a*) localized inflamed areas; (*b*) granular areas; (*c*) utriculitis; (*d*) small erosions; (*e*) dilated and inflamed follicles; (*f*) diverticula; (*g*) papilloma; (*h*) bullous edema; (*i*) polyps. The high frequency fulgurating current applied through a water-dilating urethroscope, such as McCarthy's, affords the best means of treating the majority of the above-mentioned lesions.

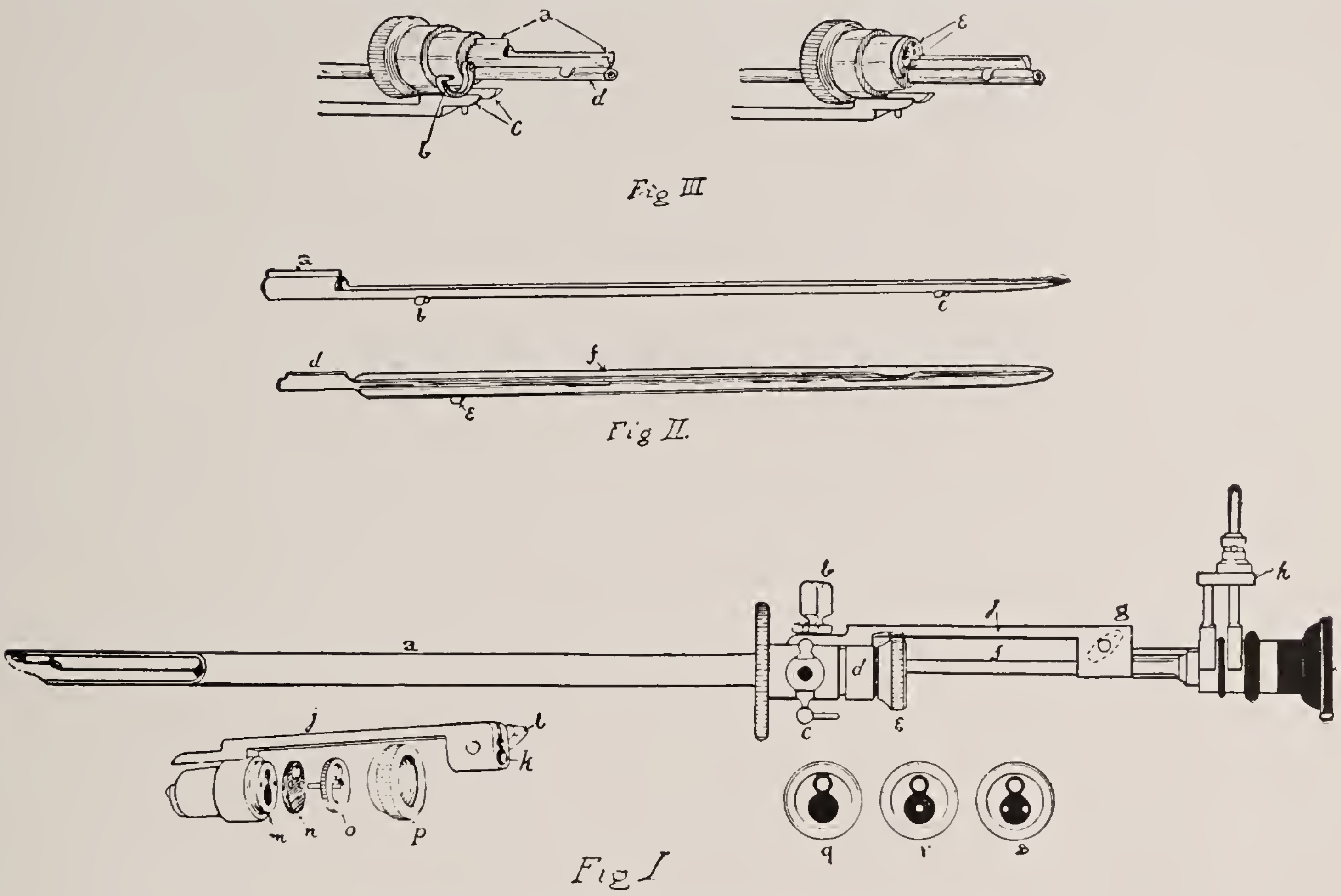

FIG. 18. The McCarthy panendoscope.

When can the patient be declared cured of gonorrhea? In the majority of instances, the genito-urinary surgeon experiences little difficulty in determining when a male patient has been cured of gonococcal infection. If the patient is free of discharge from the urethra, if the urine is free of pus, if the urethra is normal in caliber, if instrumental examinations and alcoholics do not cause a discharge or pyuria, and if the patient remains well when untreated for two or three months, it is reasonably certain that he is cured.

All of these favorable conditions, however, may not exist. Then uncertainty arises and additional tests are required, especially if the patient wishes to marry. Patients who have non-specific infections of the urethra and adnexa, following gonorrhea, present the most serious difficulty.

Gonococcal infections have a characteristic which is lacking in the majority of other urethral infections, namely, the tendency of the gonococci to recrudesce following alcoholic excess, instrumentation, or sexual indulgence. Coitus, however, does not always result in a flare-up. If there should be a seminal vesiculitis, the emptying of the contents of the vesicle may induce improvement. A study of the semen collected in a condom specimen affords data of value.

Except in the most stubborn and unusual cases, gonococci are rarely found after two or three years, unless there have been reinfections or recrudescences.

Sulfanilamide has greatly increased the difficulty of knowing when a patient is cured of gonorrhea. This difficulty has to do both with the patient and the gonococcus. The symptoms often are kept under control for a surprisingly long time after sulfanilamide has been discontinued. This remedy also may change the morphology, as well as the staining characteristics of the gonococcus. For routine work, the clinical symptoms, reactions to instrumentation and dissipation tests are usually sufficient to determine whether or not the patient is cured. If the patient desires to marry (or if he is already married) greater care is required. In such instances the most dependable means of finding if gonococci are present is by the culture method. The improvement in recent years in culture media for gonococci has made it possible to identify these bacteria by culture with a very considerable degree of accuracy. The technic, however, must be carried out by a bacteriologist who is thoroughly familiar with the cultural characteristics of the gonococcus.

Complement-fixation test. Miller and Oppenheim, utilizing the ideas of Bordet and Gengou and later applied clinically by Brück and Wassermann in the diagnosis of syphilis, found in 1906 that gonococci produce a definite anti-substance in the blood which can be detected by tests employing the complement-fixation principle. Others who carried on extensive researches along this line were Teague and Torrey, Thomas and Ivey and David Thomson.

The complement-fixation test, when carried out by expert serologists, with polyvalent gonococcal antigen, affords an accurate method of detecting gonococci where the lesions are more or less gross, as in gonorrheal arthritis and tubal infections, but a negative reaction cannot be depended upon where the lesions are small or where the infection is in the anterior urethra.

Thomson found that nearly every patient with gonorrheal rheumatism has a positive test and that ordinary rheumatoid arthritis gives negative reactions. Extensive work with this test led him to the conclusion, furthermore, that reliable information can be obtained from its use in women having pelvic inflammation and that it affords a valuable test of cure in both male and female.

Cutaneous reactions from the injection, as in the von Pirquet test for tuberculosis, have proved too uncertain to be of value in the diagnosis of gonorrhea. Cherri and di Palma assert that it is useless in gynecologic cases.

NON-SPECIFIC URETHRITIS

Etiology. When urethritis is the result of some other cause than the gonococcus, it is called non-specific. This type of urethritis, when acute, is usually associated with trauma, instrumentation, irritating prophylactic measures, or excessive indulgence in alcoholics or coitus. The organisms generally present in the discharge from the urethra are the colon bacilli, staphylococci, the so-called pseudogonococci, and others. Non-specific urethritis also arises, occasionally, in infections such as influenza, typhoid fever, and arthritis.

The chronic non-specific urethritis most frequently seen is associated practically always with focal infections in the urethral glands and adnexa, and with strictures of the urethra. As such, it should be regarded as a symptom rather than as a disease.

Symptoms. The symptoms of non-specific urethritis are acute, subacute, and chronic, and may simulate gonococcal infections in every respect except that the latter are more severe. The presence of the organisms is the determining factor in making the diagnosis.

Acute complications such as prostatitis, seminal vesiculitis, and epididymitis, are less frequent and less severe, as a rule, than in gonorrhea.

Prognosis. In the majority of instances, the acute non-specific urethritis will subside with mild injections, irrigations, sitz baths and forced fluids by mouth. The contributive factors should be eliminated when possible. In chronic cases, there are nearly always focal infections, strictures, prostatitis, or seminal vesiculitis, and the prognosis depends upon the eradication of these affections.

Treatment. The treatment of non-specific urethritis differs little from that employed for gonococcal infection. In the majority of acute cases, little if any treatment is required. The chronic forms will not disappear until focal infections and strictures have been cured. Success in the treatment depends upon finding the abnormalities and applying the measures necessary to eradicate the foci and enlarge constrictions to normal. The management of chronic urethritis is essentially the treatment of complications and strictures. The urethral discharge will disappear permanently only after appropriate measures have been applied for the abnormalities and anomalies present.

TUBERCULOSIS OF THE URETHRA

Tuberculosis of the urethra is comparatively rare and is always secondary to tuberculous infections elsewhere in the genito-urinary tract.

Pathology. The process is similar to tuberculosis in the bladder and elsewhere. The lesions may be in the urethra and around it. As the tubercles are rarely observed and recognized early, the disease usually has progressed to the ulcerative stage before it is noticed. The experimental work of George Walker has shown that there are three stages of urethral tuberculosis: (*a*) minute tubercles; (*b*) larger tubercles and ulcerations; and (*c*) caseous infiltration. Caseous infiltrations are sometimes found in the periurethral tissues, corpora cavernosa, and in the deep urethra and surrounding prostate.

Pelouze has pointed out that small masses sometimes observed in the deep urethra may be regarded as suggestive of incipient tubercular infection. A diagnosis of tuberculosis may be suspected from these masses before it is possible to find tubercle bacilli elsewhere. According to Pelouze, these lesions are likely to develop into tubercles. They appear to undergo a cystic change and later to caseate.

Viewed through the urethroscope, the masses are seen to vary in size; they are of pearly white, rarely red, color, and small blood vessels traverse the unbroken mucosa overlying them. Urethral tuberculosis appears to begin beneath the epithelium which is later invaded, resulting in minute tubercles.

Etiology. Little is known of the reasons for the local development of urethral tuberculosis. Trauma probably plays an important part, as possibly do chronic urethral lesions. It is believed that urethral tuberculosis is never contracted through sexual intercourse.

Symptoms. The symptoms of tuberculous urethritis in its early stages vary little from chronic urethritis due to other causes. As the disease progresses, however, urination becomes more frequent and pain increases. There is likely to be hematuria and quite often bladder and prostatic infections mask the tuberculous affection of the urethra.

The discharge is usually scanty and may be tinted with blood. Tender, indurated areas may be felt along the urethra and instrumental examination will detect points of extreme tenderness.

Diagnosis. The character of the urethritis is suspected from the frequency of urination, tenesmus and discharge, and is supplemented by finding points of extreme tenderness in the urethra. When observed through the cystoscope, small ulcers may be seen in areas of pale mucosa. The lesions resemble those found in tuberculous bladders. The extreme thickened areas of the urethra and periurethral tissues may render the passage of urethral instruments difficult when the affection is a tuberculous stricture. There may be fistulous tracts in the perineal or scrotal region from which the stained secretion may show tubercle bacilli.

Prognosis. The prognosis of urethral tuberculosis is usually contingent upon the primary tuberculosis of the kidney or epididymis and the secondary infection of the bladder, prostate, and seminal vesicles. The removal of a tuberculous kidney or epididymis may cause urethral lesions to heal, but, unless favored by such a possibility, the prognosis of urethral tuberculosis is grave.

Richter reports two cases of tuberculous stricture of the urethra in which dilatation with sounds was followed by miliary tuberculosis, causing death within a short time. Richter also reports a case of tuberculous periurethritis with secondary infection, miliary tuberculosis and sepsis, the primary lesion being perhaps in the urethra or in the seminal vesicles.

The sounding of urethral strictures which are thought to be tuberculous should be done, if at all, with extreme caution.

Of the 13 cases of urogenital tuberculosis with urethral strictures reported by Richter, it was possible to remove the primary focus by nephrectomy in 9, and in 8 the operation was followed by healing of the urethral tuberculosis.

Treatment. The treatment of tuberculosis of the urethra is to a great extent like that of tuberculous cystitis. Urethral injections afford little relief. Carbonizing isolated ulcers may give temporary relief but strictures are likely to follow if the lesion is extensive. Radical surgical measures are to be thought of only in connection with the primary lesions of the epididymis and kidney. General supportive and palliative measures are to be recommended, as for tuberculosis of the genito-urinary tract. Local measures are not tolerated well and extreme care should be taken to prevent secondary infection, to which patients suffering from tuberculosis of the urethra seem particularly susceptible. Abscesses which form in the perineum should be incised and drained. Cystotomy for drainage is not to be recommended as long as the urethra remains reasonably patulous.

SYPHILIS OF THE URETHRA

The meatus is a rather frequent site for the development of a chancre, which may extend along the urethra for a variable distance and cause itching, pain, and a discharge less purulent than that observed from urethritis from other causes. Endo-urethral chancres are comparatively rare, though Fournier reported that of 114 chancres, 32 occurred at the meatus, of which 17 might have escaped notice; while Thompson, in a series of 216 genital chancres, found two in the urethra.

Diagnosis. The character of the induration and the incubation period of about 21 days lead the surgeon to suspect chancre. If the *Spirochæta pallida* is found in the expressed serosanguineous exudate, a diagnosis of syphilis is made.

Secondary lesions. Syphilis of the urethral mucosa occasionally causes an opalescent discharge, usually in the mornings. A dark-field examination may show the presence of *Spirochæta pallida*, or the diagnosis may be made by the prompt clearing up of the discharge after anti-syphilitic treatment.

Tertiary lesions. Tertiary syphilitic lesions of the urethra occur as ulcerations and gumma. The latter may be circumscribed or diffuse. Occasionally the softening and ulceration result in severe hemorrhage. Cylindroid syphiloma of the urethra is a regular, gummatous, cylindric thickening which upon palpation feels like a sound in the urethra. It is rare and occurs in two forms: the sclerotic, which causes a stricture resistant to treatment; and the sclerogummatous. Fistulas are frequent after the gummatous lesions of the urethra break down.

AFFECTIONS AND LESIONS OF THE DEEP URETHRA OTHER THAN URETHRITIS

In the deep urethra of the male the urinary and genital tracts meet. It is, therefore, not surprising to find in this region affections associated with or causing bed-wetting in childhood, masturbation in youth, sexual disturbances and inflammatory processes in adult life, and urinary obstruction in old age. Among the various areas of the human body readily accessible for diagnosis of chronic conditions, none is more neglected than is the deep urethra. Unlike ancient Achilles, protected by a perfect armor except at the heel, modern man has his most vulnerable point at the prostatic urethra, where its many lesions, major and minor, result in effects and bi-effects, near and remote, with a great variety of symptoms, leading and misleading, which demand more attention to this greatly neglected area than most urologists devote to it.

The widespread neglect of this part of the genito-urinary tract may be attributed to several factors. Early cystoscopes were primarily designed to recognize and treat affections of the bladder and to permit ureteral studies and catheterization. In consequence, a routine method of bladder examinations developed. Most of the time the deep urethra was not suspected as a likely seat of urinary disturbances or it was not regarded as worthy of serious attention. Before better cysto-urethroscopes came into use, routine methods developed and these for a considerable time seemed not only adequate but even advanced.

Moreover, in the course of kidney studies, after ureteral catheters had been left in place, further study of the deep urethra was precluded; so our search for major diseases of the bladder, ureters and kidneys became restricted to a cystoscopic rut from which it was not usual to deviate unless there were symptoms definitely directing attention elsewhere. Another reason for neglect of the deep urethra is the fact that its symptoms often are referred to distant regions. Gastrointestinal disturbances, sexual affections, backache, nervousness, et cetera, frequently seem in no way connected with the prostatic urethra and yet often will promptly disappear after its abnormalities are corrected.

Unless carefully done, deep urethroscopy is somewhat more painful than is cystoscopy and in the past all of us at times have failed to find affections in this region because of our efforts to minimize pain. Another and more important cause of failure has been that too often we have seen only what we suspected and looked for, and after investigating the bladder and upper urinary tract we have been content to base our diagnosis upon the facts obtained from the bladder, ureters and kidneys, and have guessed or hoped that the deep urethra was normal. A wide variety of lesions are to be found here, and every one of us can recognize them if we but take the trouble to make a search with a good urethroscope. Among the lesions most frequently seen are: hyperemia and hyperesthesia of the verumontanum, utriculitis, papillomas, diverticula, calculi, foreign bodies, obstructing valves, fibrous contractions, obstructions of the seminal ducts, prostatic hypertrophy, bars, false passages, double deep urethra, fistulas, tuberculosis, and carcinoma.

Nearly all sexual disturbances arise from lesions of the verumontanum, while practically all obstructions are found back of it — that is, between the verumontanum and the bladder. Pathologic processes are rarely found between the verumontanum and the external sphincter.

Symptoms and urinary findings in affections of the urethra. While acute disorders of the deep urethra are very suggestive, and usually direct attention to this region, just the contrary is often true of chronic affections. The following list includes the majority of symptoms which may be associated with disturbances of the prostatic urethra: *urinary findings* may be pyuria, bacteriuria, hematuria, spermaturia and blood in the semen. *Symptoms associated with voiding* may be bed-wetting, undue frequency in voiding during the day, undue frequency in voiding during the night, weak stream, pain on voiding, dribbling after voiding and residual urine. *Sexual symptoms* may be excessive masturbation, excessive sexual desire, loss of sexual desire, premature ejaculation, slow ejaculation, absence of ejaculation, weak erection, and no erection. *Localized symptoms* may be backache, especially in the sacral region, aching in the rectum, deep-seated itching in the region of the bladder or perineum, deep-seated discomfort in the region of the bladder neck, aching in the testicle, itching along the urethra, itching at the frenum, and a sensation as if there was a drop of urethral discharge, which does not appear at the meatus. *General symptoms* may be weakness, restlessness, sleepnessness, lack of interest, loss of ability to concentrate, and poor memory. *Gastrointestinal symptoms* may be poor appetite, indigestion, hyperacidity, gastric ulcers, and auto-intoxication.

Lesions of the deep urethra sometimes exist without symptoms.

URETHROSCOPIC EXAMINATIONS

History of the urethroscope. Though many did valuable original work ahead of him, Desormeaux, about the middle of the 19th century, revived and advanced the interest in endoscopy and cystoscopy and was given the title of "Father of Endoscopy." Later Brück, a dentist of Breslau, devised an instrument called the "stomatoscope," which was unique in that it employed a platinum loop heated to incandescence by a galvanic current. His efforts to have it employed for inspection of the rectum, urethra, and bladder were, however, futile until Max Nitze, working along the same general line, devised the cystoscope somewhat as we now have it, and with the assistance of Leiter, a mechanician of Vienna, made it sufficiently practical for demonstration to the medical profession in 1879. In spite of the imperfections of Nitze's cystoscope, a start in the right direction had been made. In 1881, Grunfield constructed a tube with a glass window and studied the urethral mucosa with light reflected from a head mirror, and finally, in 1898, came the invention of the cold lamp by Charles Preston, of Rochester, N. Y. Air cystoscopes and urethroscopes soon were devised by Koch and by Valentine, respectively. Within the next few years improvements were made by Tilden Brown, Brenner, Bransford Lewis, Bierhoff, and others. Together with improvements in the design of the cystoscopes came improvements in urethroscopes. Today there are a large number of fairly satisfactory instruments, and a few which are indispensable. Successful work, however, requires both gentleness with and a thorough knowledge of the instruments themselves as well as familiarity with the anatomy of the urethra.

Varieties of urethroscopes. The selection of the proper urethroscope, which is a matter of definite importance, is determined by the peculiar need. Some urethroscopes are better for diagnosis while others are preferable for treatment. There are three main kinds of urethroscopes: (*a*) those designed to employ a clear irrigating fluid, as in cystoscopic examinations; (*b*) those in which air is used to distend the urethra; and (*c*) those in which no distention of the urethra is made with solutions or with air. There are other variations of urethroscopes according to the source of light; some having it focused from without, while others have a small electric bulb at the distal end of the instrument, the light being thrown directly upon the surface to be examined. Still other types of urethroscopes are: (*a*) those consisting of merely a tube (endoscope) provided with a lighting system which holds open and brings into view the urethra at its distal end; and (*b*) those having a prism or lens system.

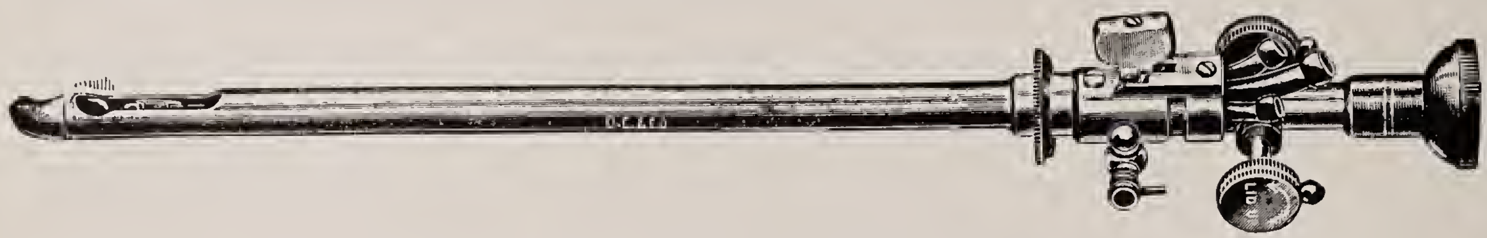

FIG. 19. McCarthy cysto-urethroscope.

The choice of a particular kind of urethroscope is determined by whether the genito-urinary surgeon wishes to make an examination, to fulgurate, to employ scissors or knives, to inject the utricle, to apply silver nitrate to the verumontanum or to carry out other endo-urethral manipulations. *The water-dilating urethroscopes for the examination, fulguration and the major part of the urethroscopic operations, are far better than the air types.*

McCarthy's Observation and Operating Urethroscope. The best of the irrigating urethroscopes is the panendoscope designed by McCarthy. The lens system is well arranged and the section bearing it also carries the light so that adjustments or replacements of the electric bulbs may be made without removal of the sheath from the bladder or urethra. A splendid field of vision is obtained and, owing to the compact lens system, adequate space is provided for urethral manipulations of various kinds, such as fulguration, the use of cystoscopic scissors or knives, catheterization of the seminal ducts, and the injection of solutions into the utricle. One of the outstanding advantages of the panendoscope is that the usual bladder investigations and manipulations may be done with it and at the conclusion of the cystoscopic work the urethra also may be satisfactorily examined as the instrument is being withdrawn. Not infrequently, urethral anomalies and affections are found at the conclusion of the bladder examinations when the urethra had not been suspected of being abnormal. The surgeon views the urethra as if it were a gun barrel. He has full view of the field of operation and of the distal end of the instrument being used, all of which permits direct manipulations with straight, rigid instruments. The urethra is visualized with the same precision as if it was seen with the prismatic cystoscopes, but without the necessary deflection of the instruments. The telescope is adjustable in length and may also be employed with sheaths of varying caliber.

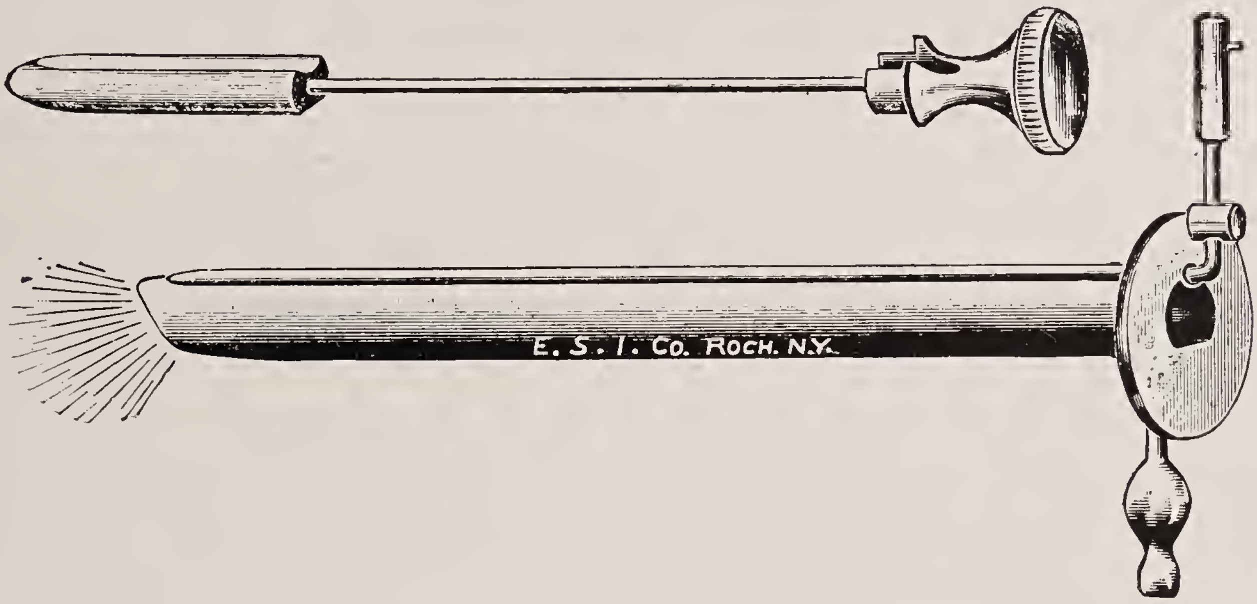

Fig. 20. The McGowan urethroscope.

Other Urethroscopes. Young has devised a urethroscope for intraurethral operations employing an external source of light and air distention. By a tube obliquely placed at the outer end, near the edge of the glass plate, it is possible to introduce instruments and operate in the urethra. For clearness of view and ease of manipulation the irrigating panendoscope is, however, superior.

McGowan modified the Koch urethroscope and made use of the Luys aspirating tube. The field of vision is not magnified. Abnormalities of the urethra are not so readily observed nor are manipulative measures as easily executed as with the irrigating urethroscopes.

The urethroscope with a curved beak, suggested by Lowenhardt and modified by Swinburne, was later modified by Ballenger and Elder so as to obtain an instrument with rounded edges, making it unnecessary to employ an obturator. Where the diagnosis has already been made and it is desired only to apply silver nitrate, or some other remedy, to the verumontanum, this instrument saves time for the surgeon and discomfort for the patient. The deep urethra is observed as the urethroscope is introduced and the verumontanum comes into view before the instrument is carried deep enough for the entrance of urine which by its removal causes delay or bleeding.

Surgeons usually accomplish better work with the instrument they are familiar with until experience has been acquired with new ones which may have special advantages.

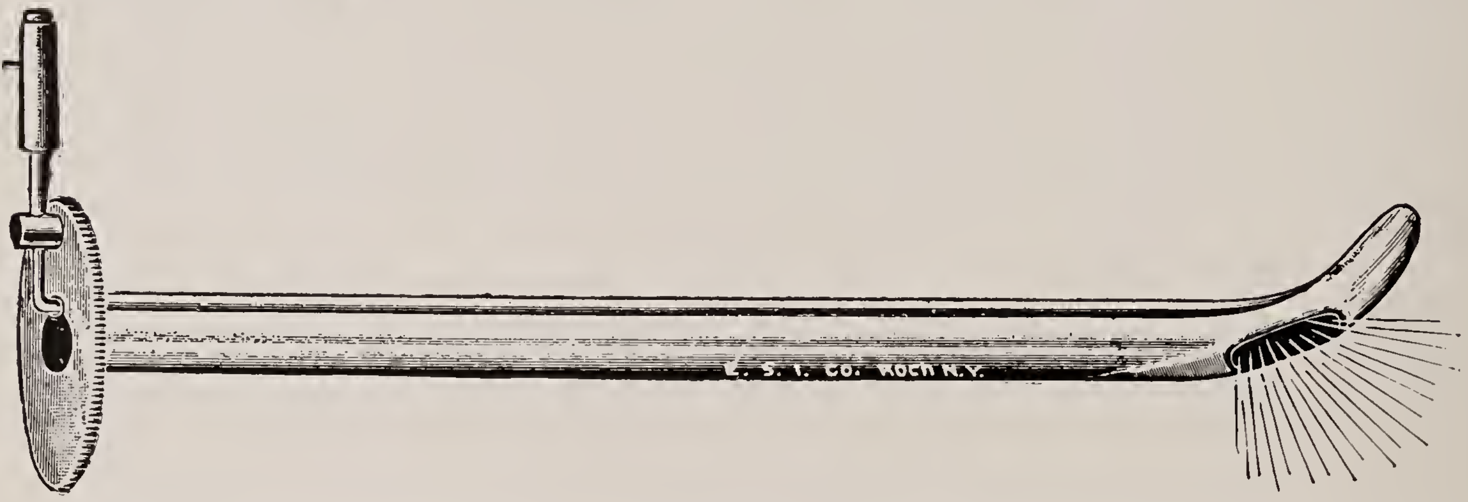

FIG. 21. Ballenger and Elder urethroscope. An obturator is not required as the sharp edges are rounded and the urethra may be observed during its introduction, lessening the likelihood of carrying it deep enough for the entrance of urine which causes delay or bleeding in its removal. It is chiefly of value in applying chemicals to the verumontanum.

Accessories required, or likely to be needed, for urethroscopic examinations. The preparation for urethroscopic examinations should include a meatotomy knife; an anesthetic solution with a hypodermic syringe for injecting novocaine, if a meatotomy is necessary; sounds to dilate the urethra, if required; an anesthetic solution and urethral syringe; lubricant; urethroscopes; evacuator; silver nitrate solutions, 5 to 20 per cent.; cotton swabs on stick applicators; platinum loop and slides; endo-urethral instruments such as probes, curettes, forceps, electrodes, scissors, and a high frequency machine. For the water-dilating urethroscopes, an adequate supply of irrigating solution should be provided.

Contraindications. Urethroscopic examinations should not be made in acute or subacute urethritis nor when there is a urethral stricture sufficiently small to cause trauma when the urethroscope is introduced. In such instances, it is always better to treat the inflammation with the milder measures until it is well under control, preferably until the urine is clear except of threads; and strictures should be dilated until they readily admit the urethroscope.

Urethral analgesia and anesthetics. There is a great diversity of opinion as to the advisability of the routine employment of local anesthetics in the urethra. Some genito-urinary surgeons think that gentleness is sufficient and assert that from a study of the fatalities recorded in medical literature the injection of local anesthetics is not justified, claiming that if the agent is strong enough to be of value it is dangerous, or if diluted enough to be safe it is useless. On the other hand, there are equally capable men who frequently use the more or less concentrated anesthetics in the urethra without harmful effects. There is probably a middle course which is both safe and effective if proper care be taken. The use of cocaine in the concentration necessary to produce complete anesthesia is unwise; indeed, this is almost never required in ordinary urethral work. Adequate superficial analgesia for the usual manipulations is produced by the injection of a one per cent. solution of novocaine, if it is retained for five minutes. Where prolonged work is to be done in the deep urethra, a few tablets of one grain each of novocaine are placed in the urethra with the Bransford Lewis tablet depositor. Solutions are not retained in the deep urethra in sufficient quantity to accomplish the same degree of analgesia that can be obtained in the anterior urethra. Reasonable anesthesia is produced by these measures and the sharpness of the pain is eliminated; not, however, with the idea that roughness then may be permitted but rather to make the treatment not so unpleasant as to prevent the patient from continuing with the desired measures until dismissed. Usually the ones most in need of urethral dilatations and urethroscopic manipulations are those in whom the pain is greatest. Experience shows that there are more patients being harmed by refusing urethral treatment than have ever been harmed by local urethral anesthesia properly employed.

The efforts to minimize the improper or careless use of urethral anesthetics are laudable but it does not seem necessary or even desirable to abandon this mode of anesthesia simply because its misuse in some quarters has done harm.

Where diagnosis alone is the object of the urethroscopy, concentrated local anesthetics or the tablet depositor should not be employed. Cocaine blanches the inflamed areas of the mucosa and in this manner removes an important diagnostic feature.

Self-induced gas oxygen affords the most satisfactory method for obtaining anesthesia for urethroscopic procedures which cause pain.

Sacral anesthesia may be sufficient at times in urethroscopic work but cannot be depended upon with certainty.

Spinal anesthesia is rarely to be advised for the usual urethroscopic work, and the same may be said of general anesthesia.

Urethroscopy with endoscopes. Since the advent of cysto-urethroscopes and the panendoscope, the straight or curved urethroscopic tubes are little used except for topical applications.

The technic of using the endoscopic tubes is as follows: The bladder is emptied, the urethra injected with 1 per cent. novocaine solution, the patient is placed in a modified lithotomy position with the head of the table lowered as in the Trendelenburg posture, the tube is introduced, and any remaining urine or novocaine solution is aspirated or mopped out with cotton applicators. Inspection is made as the urethroscope is withdrawn, and treatments or applications are administered as indicated.

Urethroscopes provided with means for dilating the urethra with air to hold apart its folds are employed in much the same manner. The air is pumped into the urethra with a two-way bulb.

Urethroscopy with cysto-urethroscopes and panendoscopes. The above-mentioned methods are not employed by the majority of urologists for diagnostic purposes or for treatment except as stated. For making electrical applications to the deep urethra and verumontanum, the cysto-urethroscope and the panendoscope are immeasurably better than endoscopic tubes.

The position of the patient and the technic employed for urethroscopy are practically the same as for cystoscopy. The irrigating solution is allowed to flow in the manner suggested and distend the urethra as the observations are made; blood is washed away immediately and does not interfere with the recognition of existing abnormalities or treatment. The panendoscope permits the urethra to be viewed as if looking down a gun barrel and, therefore, does not require rotation, as do cysto-urethroscopes.

Among the pathologic changes to be noted in the deep urethra may be mentioned edema, hyperemia, urethritis cystica (chronic), papillomas, leukoplakia, prostatic hypertrophy, and diverticula. The lesions of the verumontanum to be looked for are hyperemia, enlargement, granular areas, vegetations, papillomas, adhesions, inflamed orifices of the utricle and abnormalities of the ducts of the seminal vesicles.

In the membranous urethra may be seen the contractions of the external sphincter and strictures. In the anterior urethra the urologist is chiefly concerned with its caliber, inflamed glands of Littré, granular areas, the lacunæ of Morgagni and neoplasms.

Diagnosis of lesions of the deep urethra. The diagnosis of nearly all affections of the deep urethra are easily made if this area is carefully studied with a good cysto-urethroscope, such as the McCarthy panendoscope.

Symptoms cannot be relied upon except in focusing attention upon the prostatic urethra; they are of great value, however, in leading to investigations which ultimately result in correct diagnosis.

Papilloma, cysts, bars, bands, diverticula, patulous ducts, false passages, double deep urethra, bullous edema, abnormalities of the verumontanum, utriculitis, contractions or bars at the vesical neck and hypertrophy are readily recognized when seen through a cysto-urethroscope. They are almost surely overlooked, however, in casual cystoscopies with instruments designed solely for bladder work. In carcinoma of the prostate, the boardlike hardness, when palpated per rectum, is of more diagnostic value than is the cystoscopic picture. Calculi of the prostate are shown on x-ray films; often, though, in studying the films they are not observed, because their existence has not been suspected. Hyperemic and hypersensitive conditions of the verumontanum are readily detected by the introduction of sounds and by endoscopy.

Large diverticula, easily recognized by urethroscopic examinations and by urethrograms, usually receive the needed attention, but until recently the smaller ones, of more importance as far as focal infection is concerned, generally have been neglected.

Urethrograms and sometimes cystograms may prove of value in the diagnosis of vesical neck and deep urethral affections. At times foci of infection in the prostate are readily suspected and easily recognized; at other times, they may be quite elusive. The chief trouble with urologists is not their failure to find the pus expressed by massage from these foci but their failure to recognize the lesions and pockets endoscopically and to employ modern means to eradicate them. Merely to continue massage of the prostate indefinitely, because pus can be expressed at each treatment, is wholly inadequate. The history of symptoms of long-standing chronic prostatitis, or of recurrent prostatitis, should lead to a cysto-urethroscopic examination. This examination, however, should not be made until after sufficient massage and other treatment have been given to allay the inflammatory processes. An exception to this rule is when in the course of treatment and study, urethroscopic examinations are negative; in such cases, urethroscopy during a subacute flare-up may show pus exuding from ducts not formerly recognized as focal pockets. This statement is not by any means intended to give the impression that prostatic massage is not the most valuable treatment for subacute or chronic prostatitis. It is only after an adequate course of massage or repeated courses of massage that deep urethroscopy is to be employed. Occasionally a pocket in the deep urethra can be seen only when its outlet is opened by the stream of irrigating fluid playing on it. Distant foci of infection, such as are found in diseased tonsils, abscessed teeth, et cetera, should be carefully sought and treated. Such lesions tend to act as feeders for diseased areas in the prostate and prostatic urethra. Chronic seminal vesiculitis may add considerable difficulties in making a differential diagnosis of prostatic focal infections. At times these conditions coexist.

Congenital obstructive lesions, usually valve-like formations, occur in the region of the verumontanum or posterior to it. They may be in the form of cup-like folds or redundancies of the mucous membrane or like a diaphragm. Unless viewed with a cysto-urethroscope, obstructing valves may not be recognized because sounds and catheters of good size may pass easily into the bladder and thereby mislead the urologist into thinking that a spinal cord lesion or something else is the cause of the urinary obstruction. The history of congenital valve obstructions is quite characteristic, and supplemented by a reasonable examination should lead to an easy diagnosis.

Obstructive lesions of the deep urethra, when due to bars, hypertrophy of the prostate or carcinoma, are fairly well recognized by urologists but the general practitioner and general surgeon are far from being alert in suspecting and detecting these affections until well-marked symptoms have occurred. Studies of the deep urethra, when obstructive prostatic symptoms are present, should include the measuring of the distance from the innermost point of the vesical neck, or middle lobe, to the verumontanum. This is readily done by an assistant holding a rule along the side of the cysto-urethroscope as it is withdrawn. This measurement varies from ½ to 4 or more inches.

A point of value in reaching a correct diagnosis, when urinary obstructive lesions are suspected, is comparison of the patient's present voiding distance with the former distance the urinary stream could be thrown. Another test with about the same significance is the voiding rate; that is the number of cubic centimeters of urine the patient, with a full bladder, can void per second. The normal varies from 10 to 30 cc. including starting and finishing. These tests are of considerable value.

Benign tumors and cysts usually occur at the vesical orifice or in the region of the verumontanum, while pockets or small diverticula are most frequently seen on the floor of the deep urethra near the verumontanum and between it and the bladder neck. These small pockets or focal infection are frequently neglected by urologists.

Definite angiomas in the deep urethra are rare, but varicose veins are of rather frequent occurrence and troublesome bleeders may follow their rupture. Bleeding may occur spontaneously, may be a terminal hematuria or may result only from instrumentation.

A search for the cause, or causes, of persistent bed-wetting, excessive masturbation and sexual disturbances in males usually will be rewarded by finding definite pathologic processes in the deep urethra.

Sexual disturbances in the male. Most psychiatrists and medical men, as well as some urologists, think sexual disturbances are largely psychic or due to age and have little or nothing to do with affections of the deep urethra. Excepting senile patients and those with sexual perversions, we are in complete disagreement with this opinion. While admitting the importance of the psychic element, the diagnosis and treatment of lesions of the deep urethra afford the most direct and satisfactory means of overcoming the existing handicaps, even when psychic. As the average man is reluctant to admit his sexual weakness, one of the most important factors is to obtain the patient's confidence and, by tactful and leading questions, to elicit the admission of such disability. Confidence, however, usually cannot be obtained without a painstaking examination. A large percentage of patients with sexual disturbances, poor erections and lack of sexual desire are overlooked because leading questions are not asked in history-taking. When sexual weakness is suspected, more frank information is obtained if the patient is asked, not " Are you sexually weak? ", but " How long have you been weak sexually? " or, after some particular trouble has been found, " How long has it been causing sexual weakness? " Many patients think premature emissions are temperamental characteristics and have no idea that most of the time they are caused by definite lesions of the verumontanum and the urethra or prostate surrounding it, which produce the precipitate ejaculations. As regards the age factor, we may compare the sexual organs to automobiles; cars are not discarded just because trouble has arisen. Proper repairs may add thousands of miles of useful service even to old cars and again they may be nearly as good as new; at least much better than they were before the repairs or adjustments were made.

Small anemic-looking penises, or those which are large and flabby, should suggest the likelihood of sexual weakness, regardless of the patient's admission. Many with sexual weakness, without discernable lesions, will obtain excellent results from the treatment ordinarily employed for hyperesthesia or hyperemia of the verumontanum. The question of sexual perversions is largely of interest concerning the prognosis, but such discussion would take us too far afield.

Treatment of affections of the deep urethra and of sexual weakness. The treatment of most of the lesions of the prostatic urethra is quite satisfactory, once the diagnosis is made. Sufficient preliminary treatment of urethral and prostatic inflammations should be given to bring acute or subacute conditions well under control before the employment of cysto-urethroscopic measures. Meatotomy should be done if a 26 F. bulb cannot be introduced into the urethra. Strictures, if present, should be dilated sufficiently to permit easy instrumentation. Preliminary treatment with urinary antiseptics should be administered if past experience has shown that the patient is likely to have an inflammatory flare-up or urethral chills and fever following instrumentation. In such instances sulfanilamide, 40 or 50 grains daily for 2 days before, or hexamethylenamine intravenously before, or perhaps after, cysto-urethroscopic treatment, lessens the tendency to chills and fever.

Apart from the massage of the prostate, treatment of urethritis and dilatation of urethral strictures, there are two agencies upon which we rely for eradication of most of the disorders and lesions of the deep urethra. The therapeutic agencies here referred to are high frequency current and silver nitrate. The former is employed for all abnormalities except those involving the verumontanum, and even here the high frequency current is used to destroy neoplasms; our experience, however, has led us to the opinion that topical applications of silver nitrate are much better than is high frequency current for hyperesthesias and hyperemias associated with sexual disturbances. In order to lessen the pain associated with applications of silver nitrate to the verumontanum, an endoscope with rounded edges is employed so that an obturator is not needed. The urethra is observed during the introduction of the endoscope. When the verumontanum comes into view, phenol, 50 per cent., in glycerine (Grant's solution) is applied with an applicator wrapped with cotton. This smarts for a second but immediately its anesthetic action becomes effective. Silver nitrate usually a 20 per cent. aqueous solution, is then applied to the verumontanum. The pain, both immediate and late, is as a rule insignificant and rarely is sufficient to cause the patient to cease the treatment, as patients often did after ordinary applications of silver nitrate. This type of endoscope is not of value for diagnosis but is used only for treatment.

For years we have used the fulgurating current for destruction of neoplasms and valves of the deep urethra, as well as tissue overlying calculi, pockets, cavities or tunnels found in this region, when these lesions appeared to be productive of symptoms or when there was reason for believing they harbored infection. Since the advent of the cutting current, its use at times has greatly facilitated the removal of pocketed foci by resection or by the removal of the roof of tunnels, diverticula and false passages in the prostatic urethra. With this current, blind pockets are made into open grooves or, if possible, they are entirely resected.

The coagulating current is employed for neoplasms, cysts, and bullous edema. The cutting current is used for most of the obstructing lesions, benign or malignant.

Stones in the prostate may cause pain, frequency and bacteriuria; in such cases the calculi may be freed by fulguration or transurethral resection of the overlying tissue, after which the stones may be removed by cystoscopic forceps or by the resectoscope loop; or, if of large size, the stones, after being freed and pushed into the bladder, may be crushed with a Ravich lithotrite and washed out.

STRICTURE OF THE URETHRA

General considerations. The term stricture is derived from the Latin word *stringere*, to bind, and may be defined broadly as a diminution in the caliber of the urethra due to a deposit of fibrous tissue produced by inflammation or injury of the wall of the urethra. There is a congenital narrowing of the urethra differing from the above-mentioned type in that there is no deposit of fibrous tissue at the stricture. There may be also a spasmodic condition of the urethral muscles, perhaps temporarily simulating a stricture of the urethra, but differing greatly from the narrowing due to an organized infiltrate or cicatricial tissue resulting from inflammation or injury of the urethra. It should be remembered that these different types of obstruction may coexist. A fibrous deposit may occur at a point congenitally narrow, or a spasmodic contraction of the external sphincter may be associated with other urethral narrowings. Sufficient encroachment upon the lumen of the urethra to cause retention of urine or to prevent the passage of catheters or instruments may be caused by urethral, periurethral or prostatic inflammation or abscesses; this condition, however, should not be classed as urethral stricture, though one may be present, which would naturally complicate the above-mentioned affections.

The average genito-urinary surgeon administers treatment for urethral strictures with more precision than he utilizes in their recognition; he usually knows that gradual dilatation is the best treatment, if feasible, but he fails to suspect strictures as the cause of or related to many symptoms seemingly not assignable to urethral obstructions. Among the symptoms which should suggest causative factors are: chronic inflammatory affections of the urethra or adnexa; urinary disturbances; sexual symptoms of nearly every kind; hematuria; pain in the region of the pelvis and sometimes more remote from the urethra or genitals; itching in the urethra or perineum; and many other symptoms less frequently associated with strictures of the urethra.

The symptoms usually regarded as pathognomonic of strictures are: gleety discharge from the urethra, especially after alcoholic excess or coitus; a small or twisted urinary stream when voiding; dribbling of urine; frequency of urination; retention of urine; cystitis; frequent nocturnal emissions; incontinence of urine; periurethral abscesses; extravasation of urine; and urinary fistulous tracts. Definite urethral strictures may exist for many years

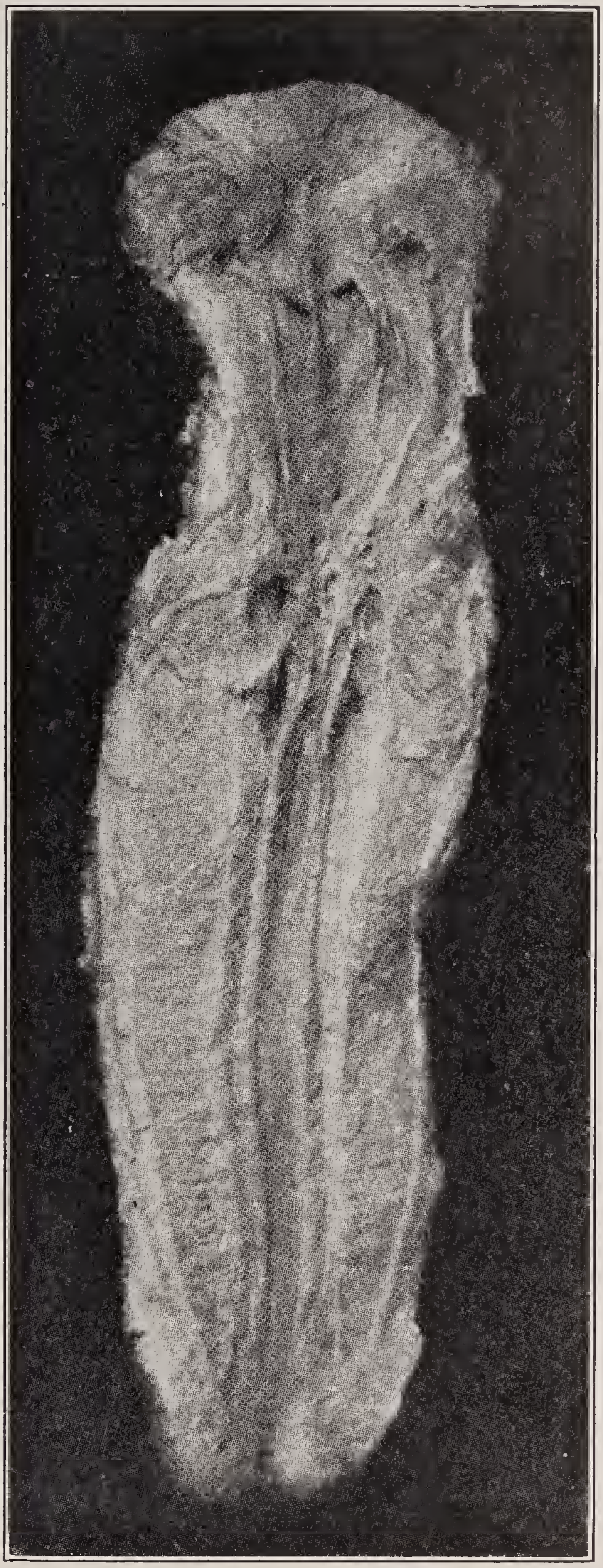

FIG. 22. Stricture of the urethra occurring at the bulbomembranous junction, which is the commonest site of stricture resulting from long-standing gonorrheal urethritis. It will be noticed that there is dilatation of the urethra both in front of and behind the point of stricture. (Courtesy of Lea and Febiger.)

without any of the symptoms mentioned above, without discharge and without pus or shreds in the urine, and may not be suspected until an intercurrent affection leads to investigation. Strictures not causing symptoms or disturbances of any kind may not require treatment until trouble arises, but the patient should be informed of their existence and the symptoms likely to arise subsequently in order that the necessary treatment may be employed if and when they develop. What percentage of the unsuspected and symptomless strictures are congenital and what part acquired cannot be estimated with any degree of exactness. When the history is negative as regards inflammation or injury, it is usually assumed that the stricture is congenital. A small meatus suggests that there are congenital obstructions, but such strictures are not always present. It appears that hernia is more frequent in boys and in men who have a pin-point meatus, and that the recurrence of the hernia is less likely, subsequently, if the meatus and urethra are made normal in caliber so that less straining effort is required to void. Strictures of fairly small caliber may exist without symptoms of sufficient moment to attract the attention of the patient or his physician, while on the other hand strictures of large caliber may cause or be associated with urinary, sexual, or other disturbances entirely out of proportion to the degree of the obstruction.

It is an error on the part of the genito-urinary surgeon to restrict his urethral dilatations to the patients who present evidences of obstruction detectable only by sounds. No set of rules can cover all of the contingencies and factors concerned in the management of these cases but, generally speaking, if doubt arises, dilatation should be resorted to.

All urethral strictures show a tendency to contract subsequently, whether dilated or incised. The rate and degree of contraction varies greatly, as does also the time they remain dilated after apparently adequate courses of treatment.

Classification of urethral strictures. Urethral strictures are subdivided into types variously designated or described according to their origin, location, size and form, caliber, degree of organization, and characteristics.

According to their origin, there are two main divisions of strictures: the *congenital* and the *acquired.* The latter group is divided into inflammatory, chemical, traumatic, and those due to burns and other causes. The rarer types of strictures are not found with sufficient frequency to justify a special classification.

Urethral Strictures in the Male
- Congenital
- Acquired
  - Inflammatory
    - Gonorrhœal
      - Focalized Infection
      - Chordee
    - Non Gonorrhœal
      - Urethritis
      - Abscesses
      - T. B.
      - Syphilis
  - Chemical
    - Strong Injections
    - Accidental
  - Trauma
    - External
    - Internal (instrumentation)
  - Burns by fire, other causes

According to location there are strictures in the penile or pendulous urethra; at the penoscrotal junction; in the scrotal or perineal portion; in the membranous urethra; and, less frequently, in the prostatic urethra.

Based upon the size and form there are: (*a*) linear strictures, like a cord around the urethra; (*b*) valvular strictures; (*c*) annular strictures, resembling a band or ring around the urethra, which may be wide, thick and regular or irregular; and (*d*) tortuous strictures which involve a considerable portion of the urethra and change it into a devious, irregular, thickened canal.

According to caliber, we have an arbitrary division into strictures of large caliber, comprising those above 15 F.; strictures of small caliber, which are 15 F. and below; filiform strictures, which permit the passage of a filiform only; and impassable strictures, which admit no instrument. Quite often a stricture is "impassable," not of itself, but because the surgeon is unskillful or because the proper instruments are not available. Owing to the fact that urine can nearly always pass, even in tight strictures, it is inappropriate to call such obstructions impermeable.

As to the caliber of the normal urethra, there has been in the past more diversity of opinion than exists today. Years ago, Otis attempted to establish a ratio between the circumference of the penis and the size of its lumen. His views are today discredited and his routine of cutting the urethra to the extremely large size he deduced was necessary is no longer followed. His assumption and teachings that the urethra was an evenly calibrated tube conforming to the above-mentioned ratio resulted in the extensive employment of overdrastic measures in the treatment of chronic urethritis.

Following the cutting measures advocated so enthusiastically by Otis, there was a reaction which went too far in the other direction and surgeons became inclined to disregard for an unreasonably long time the possibility of obstructions being the cause of persistent chronic affections of the urethra. The improvement in the urethroscopes, a better understanding of the urethral pathology and anomalies, a further study of the micro-organisms likely to be found in the urethra, and the production of better and milder remedial agents have lead to a more rational view of these affections. While the teaching of Otis was extreme, it was hardly worse than the opposite view held later by other leaders in genito-urinary surgery, that a stricture should be disregarded if not tight enough to grasp or hang onto a sound when it was being withdrawn. If strictures of this type alone are recognized, many definite affections caused by strictures of large caliber which cannot be diagnosed with sounds will not be cured.

According to the organization of the tissue in the obstructed area, there are soft and hard infiltrations. The soft ones are those recently formed and respond readily to dilatation, while the hard ones are composed of dense cicatricial tissue and yield but slowly to treatment; some show a tendency to contract rapidly when dilated. The last-mentioned variety is called resilient.

Between the extremes of the potential strictures composed of soft infiltrates and the definite long-standing strictures with the round cell infiltrate changed completely into scar tissue, there is a great variety of conditions.

The lines of demarcation between chronic urethritis kept up by infections pocketed in the urethral glands and producing the round cell infiltrations, which are ultimately to result in scar tissue formation, are practically impossible to distinguish from urethral strictures, as the late stage of the former is the early stage of the latter affection. It would require better genito-urinary judgment than any one today possesses to enable the surgeon to say always with certainty the exact conditions that justify urethral dilatations in the management of chronic urethritis or to what extent the urethritis associated with urethral strictures should be treated before dilating the urethra. The whole question is rendered more complex by the possible existence of congenital strictures and by previous infections which may have resulted in acquired strictures. Much depends upon the type of infection present, the degree of immunity, upon the extent of the contraction, and upon the complications.

Localized urethral infections may be potential strictures, but to dilate them too early may make the inflammation worse, thereby increasing the undesirable infiltrate. However, not to dilate potential strictures, which cause the persisting focal infection, may also increase the inflammatory products and in this manner cause stricture. Thus the genito-urinary surgeon finds himself on the horns of a dilemma. Often strictures are caused by the intensity of the infection and sometimes by its persistence, but practically always by the traumatism of severe or ruptured chordee.

According to their characteristics, we recognize inflamed strictures which are narrowings with definite urethritis at the strictured area. This type may result from persistence of the folliculitis at the stricture, or from a new infection. There are also irritable strictures which bleed easily, due probably to granulations at the narrow points. Urethral tuberculosis may cause strictures, as also may syphilis.

Bilharzia. Stricture of the prostatic urethra, rarely the anterior urethra, may be caused by bilharzial inflammation. (Pfister)

Congenital strictures of the urethra. Congenital strictures of the urethra differ from atresia in that the latter extends over a greater part of the urethra. Both of the affections are developmental defects. The most common type of urethral constriction is the small meatus. Strictures of the deeper part of the urethra are rather frequently associated with this anomaly. With the normal meatus, congenital strictures are rare. These strictures may be present in any part of the canal, although the embryonic urethra is developed from three distinct sources: the fossa navicularis from an infolding of the skin, the prostatic urethra from the urogenital sinus, and the intervening portion from the penile groove.

Usually the meatus is the narrowest part of the urethral canal, though not infrequently we find a fairly normal meatus with a congenital obstruction 4 or 5 millimeters back of the meatus.

The pathology of congenital strictures. The pathology of congenital strictures varies from the slight valve-like bands of mucosa to the extensive urethral constrictions bordering on atresia of the urethra. These obstructions, when there has been no previous inflammation or trauma, differ from the acquired strictures in that there is no scar tissue which constitutes the essential element of strictures which are not congenital. There is very little body to the congenital strictures and they cannot be palpated along the sound introduced into the urethra, as can most of the acquired ones.

For the management of congenital strictures, see the section on the Treatment of Acquired Strictures.

The meatus never can be dilated with satisfactory results. The technic of incising the meatus is given in the section on Meatotomy.

Acquired strictures of the urethra. Etiology. Inflammatory strictures are most frequently caused by gonorrhea. These strictures arise in several ways:

(*a*) From trauma or tearing of the inflamed, inelastic urethra. Damage done to the mucous membrane during acute gonorrheal urethritis by frequent and painful erections is repaired by fibrous tissue, which ultimately contracts and forms a stricture. The breaking of a chordee is nearly always followed by such a constriction. The use of sulfanilamide has greatly reduced the frequency and severity of chordee. In consequence, urethral strictures from this cause are being decidedly lessened.

(*b*) Continued focal inflammation and abscesses of the urethral glands result in perifollicular and periurethral round cell infiltrate which gradually undergoes cicatrization, and a stricture results.

(*c*) The injection of concentrated solutions of silver nitrate or other remedies may produce strictures.

(*d*) Rough instrumentation in the treatment of chronic urethritis sometimes may cause a stricture, which properly may be classed as traumatic, but a constriction of this type is in a way also due to the gonorrheal inflammation.

(*e*) Prostatectomy occasionally results in stricture of the membranous or deep urethra. Following transurethral resection of vesical neck obstructions strictures may arise and preëxisting ones are likely to be made worse.

(*f*) Tuberculosis, syphilis, and bilharzia may cause urethral strictures.

Pathology. The pathologic process of a stricture, except the congenital, is essentially a scar in the wall of the urethra plus the effects of urinary obstruction and infection resulting therefrom. At the site of the stricture there may be granular patches, erosions, hyperemia, or other evidences of localized inflammation. The local pathology of the stricture and that of chronic urethritis are overlapping processes, both usually having been preceded by a localized acute inflammation. While chronic urethritis and strictures may not be said to cause each other, they nevertheless are associated intimately with the preëxisting and coexisting processes.

The inflammation kept up by a stricture tends to add fibrous tissue to a narrow area. The stricture also may keep up an inflamed area in the urethra back of it. The obstruction to the urinary stream at the stricture tends to dilate the urethra back of it, but the dilatation of the bladder, with resultant residual urine, is less frequent than in prostatic obstructions. Urinary retention and sepsis of the upper urinary tract result not infrequently, however, from stricture. At times there is a compensatory hypertrophy of the bladder wall. It is not evident why prostatic obstruction should cause residual urine with such regularity, nor why strictures of the urethra, resulting in perhaps more obstruction, should not produce it more often and earlier.

Other complications associated with urethral strictures are: periurethral abscesses, extravasation of urine, fistulous tracts, stones, prostatitis, vesiculitis, prostatic abscesses, and bladder and renal retention of urine and infection.

Symptoms. As already stated, urethral strictures may be present without symptoms which might lead the patient or the surgeon to suspect their existence. A tight stricture may cause little or no urethral discharge; the obstruction to the urinary stream may be gradual in development and the patient may not notice any change in the flow of urine. Attention may be attracted first by sexual disturbances, backache, nervousness, or general debility. The most common symptom of urethral stricture is a chronic or recurrent discharge. Obstruction to urination or frequency in urination is often noted. Pain, more or less elusive, in the region of the genital organs, back, suprapubic region, or perineum, may be present. Retention of urine may be partial or complete, is often associated with inflammatory changes in the deep urethra and prostate gland, and may result, at times, from strictures of fairly large caliber. Hyperemia following exposure to cold, alcoholic excess, or voluntary retention of urine beyond the usual time, are factors which contribute to complete retention of urine. Sexual symptoms such as inadequate erections, impotency and sexual neurasthenia are often caused by urethral obstructions and the resultant changes in the deep urethra and verumontanum. Tight strictures, however, may exist without sexual disturbances or symptoms of any kind; neither this observation nor the fact that individuals who have no strictures of the urethra are benefited sexually by dilating the urethra, should be taken as proof that strictures do not play an important part in bringing about the changes that result in sexual disturbances. Painful erections similar to chordee may be observed in patients with extensive inflamed strictures. Hemorrhage from the urethral mucosa at the site of stricture, other than instrumental trauma, is not a frequent symptom but sometimes occurs and promptly disappears when the urethra is dilated. Periurethral abscesses, fistulas, and extravasation of urine may result from neglect of the stricture or from false passages produced by instrumentation.

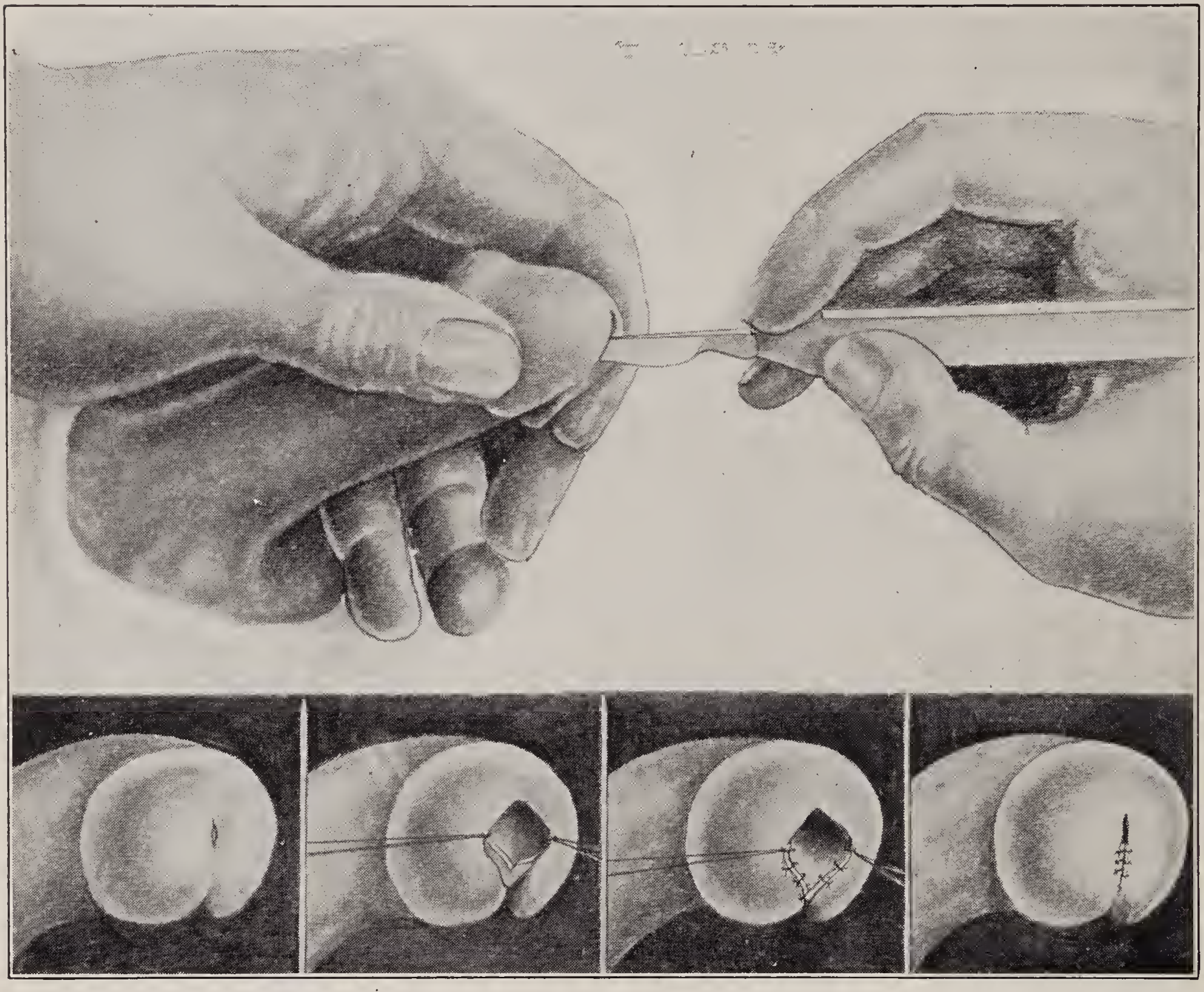

FIG. 23. *Meatotomy:* Inserts show method of closing skin to mucosa, utilizing uncut suture as a retractor to facilitate introduction of lower stitches.

Meatotomy. Unless contraindicated, meatotomy should be done when a 26 bulb will not pass through the meatus into the urethra. Recurrent non-specific urethritis, frequency of urination and sexual disturbances not infrequently are caused by a small meatus. If, in addition to a small meatus, there are also urethral strictures, it is particularly advisable to do a meatotomy.

Although this operation is, like circumcision, only a minor one, it is desirable that it be done with the minimum pain and subsequent discomfort. Formerly the procedure was rather hurriedly and crudely done; later the area was anesthetized, more carefully incised and the cut surface cauterized with Monsell's solution and such agents to stop the bleeding and pain when voiding; finally the more satisfactory method of suturing the cut edges of the skin and mucosa was utilized to prevent bleeding, pain and subsequent closure.

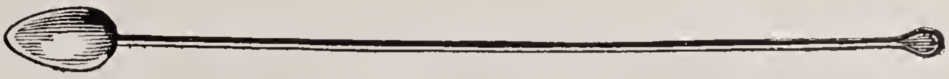

Fig. 24. Metal olivary bougie.

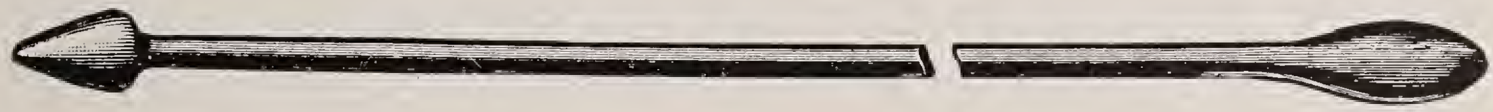

Fig. 25. Olivary and conical gum elastic bougies.

Modifying the method of Likes and Schoenrich, Ballenger, Elder and McDonald have done 210 meatotomies, using the following technic, which they assert is far preferable to the older methods: The meatus and glans penis are well cleansed and a two per cent. solution of novocaine is injected into the urethra, where it is held for a few minutes. The lower part of the meatus is anesthetized by infiltration with a few cc. of a one per cent. solution of novocaine, containing three minims of adrenalin solution, 1 to 3000; the needle is inserted, not through the skin, but through the partly anesthetized mucosa just within the anterior floor of the fossa navicularis. The meatus is incised to a 32 F. for a penis of normal size or 30 F. for those subnormal in size. Sutures of 10-day 00 chromic catgut, closing the skin to mucosa, are then placed with a small curved needle, as shown in Figure 23. The stitches are

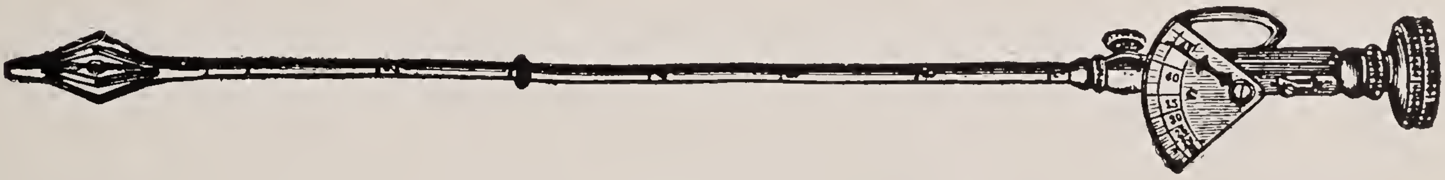

Fig. 26. Otis urethrometer.

taken at the sides first, and the first or second suture on each side is left uncut to act as a retractor while the lower sutures are being placed. Five or six stitches are usually sufficient to stop the bleeding and to close the raw area left by the incision. Bulbs are passed to determine that the lumen is still adequate after the suturing; a meatus cut to a 32 should admit a 30 bulb when sutured as described. The patient is directed to apply one per cent. mercurochrome with a pledget of cotton on an applicator twice a day for five days.

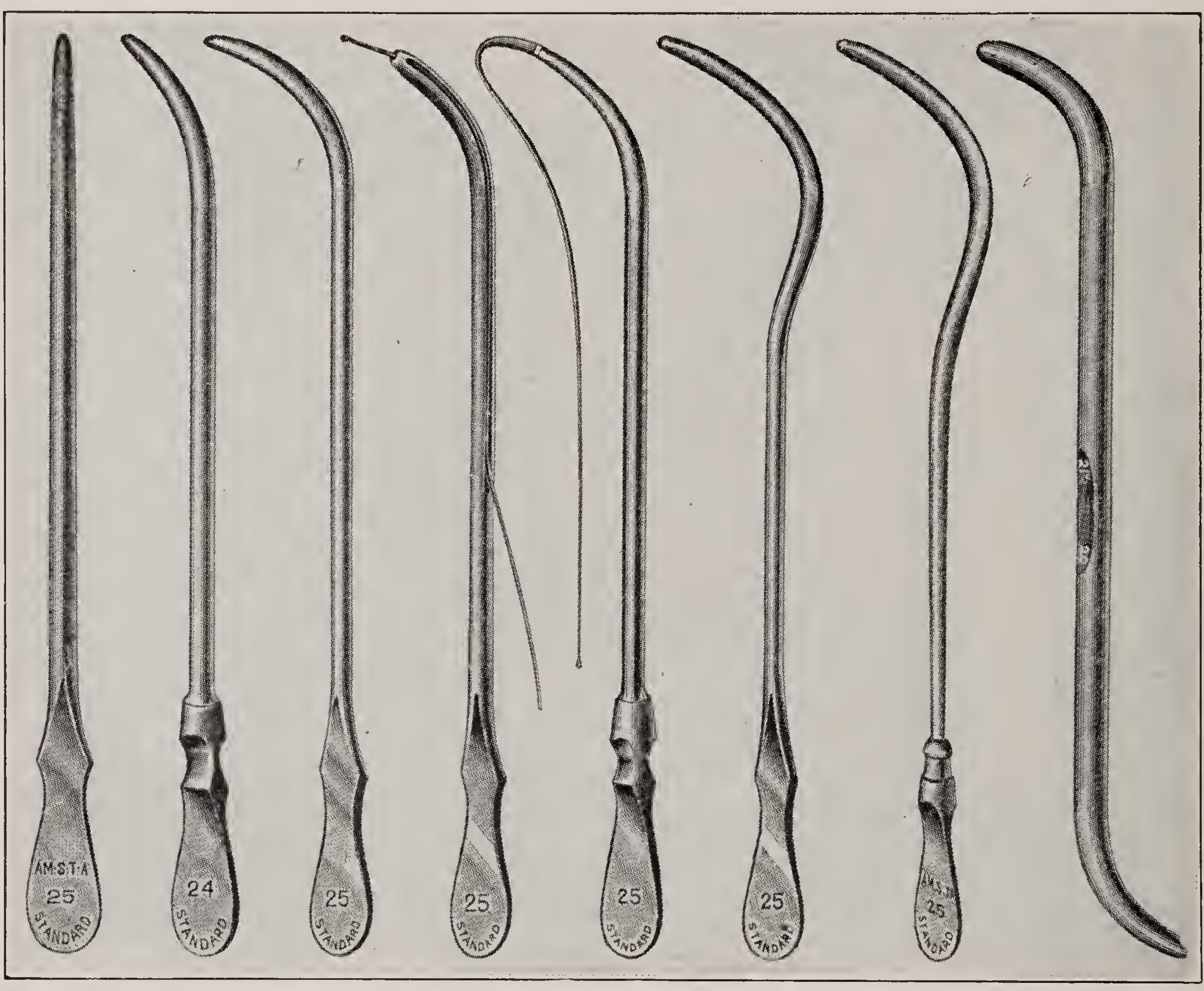

FIG. 27. Urethral sounds of different types.

This method of performing meatotomy has the following advantages: the healing is quicker; there is less pain on voiding; subsequent sounding to prevent healing of the incised area is unnecessary; bleeding is minimized; the cosmetic effect is better; and, finally, later contraction from scar tissue is quite unlikely.

Sometimes the shape of the glans, character of the narrowing, and shape of the meatus make it desirable to incise the meatus upward rather than downward.

Diagnosis of urethral strictures. Two sources of error are likely to arise in the diagnosis of urethral strictures: (*a*) normal narrowings in the urethra may be mistaken for pathologic constrictions (the use of extra large bulbous bougies or the Otis urethrometer are likely to lead to such mistakes); (*b*) on the other hand, difficult urination or retention of urine may be attributed to stricture when the trouble is due to pathologic lesions of the prostate, a spasmodic condition of the sphincters, diverticula, valves, or to lesions of the spinal cord.

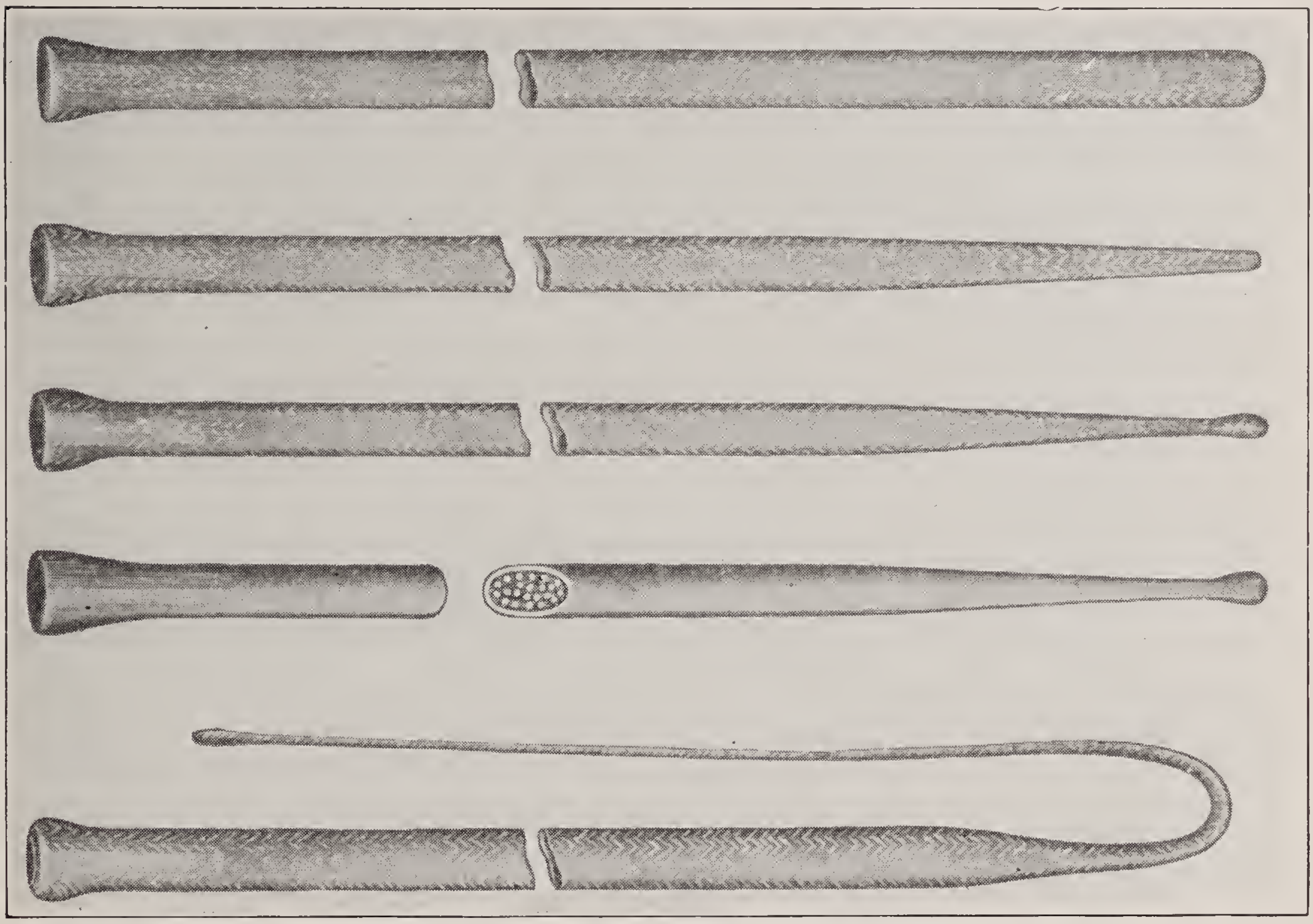

FIG. 28. Gum elastic and shot bougies.

The history and symptoms may or may not be of value in reaching a diagnosis. Only after an examination of the urethra with bulbous bougies can the surgeon determine that strictures are absent. The examination should be started with the largest size bulb that will enter the meatus. If no obstruction is met, the instrument is gently passed down to the bulbous urethra. If a stricture is encountered, smaller bulbs are tried until one passes the constriction. The obstruction met when introducing the instrument, as well as the hang of the bulb, when removing it, are characteristic of urethral stricture. When the meatus is smaller than 26 F. it should be incised. If there is an adequate reason why meatotomy should not be done, an Otis urethrometer may be employed to determine the caliber of the urethra.

On account of the hang caused by the external sphincter, flexible woven bulbous bougies are rarely advised for the diagnosis of strictures of the deep urethra. Sounds should be introduced to determine the patency of the membranous and prostatic urethra. As previously stated, however, sounds cannot be depended upon for the diagnosis of strictures of large caliber in the anterior urethra. Furthermore, inflammatory exudates resulting from localized infections cannot be recognized with any degree of certainty with sounds.

Spasmodic contractions of the external sphincter may simulate stricture. The use of novocaine, gentleness, and fairly large sounds, will usually enable the surgeon to pass instruments into the bladder in spite of the contracted sphincter. The tip of the sound should be carried along the roof, not the floor, of the urethra. Slight traction on the penis or gentle pressure in the region of the bulbous urethra assists in passing the sound through the sphincter. Spasmodic contractions permit more extensive dilatations with the Kollmann dilator than do strictures. Sometimes sounds which cannot be introduced while the patient is awake, will pass readily when the patient is anesthetized.

Symptoms of urethral strictures. Tight congenital strictures in the new-born are usually promptly fatal due to the enormous renal and urethral dilatations which, if present before childbirth, may interfere with parturition. Heinecke observed that this variety of congenital stricture was generally to be found in the region of the verumontanum. If not fatal early, the condition may attract little or no attention until some time between the fifth and tenth years, when persistent nocturnal incontinence of urine, hematuria, pyuria, renal affections, malnutrition, or other affections may occasion an investigation of the urethra.

The presence of fibrous tissue in a stricture indicates that previous inflammation, trauma, or other damage has existed, even though the constriction was at first congenital.

Dilatation of the upper urinary tract, with inflammation and infection, may result from congenital strictures just as from other obstructions of the urethra; complications such as fistula may also be present.

Congenital strictures of medium size may or may not produce symptoms which lead to their detection. Prolonged incontinence of urine and more than the usual amount of masturbation in boys should suggest the likelihood of urethral strictures and the associated irritation of the deep urethra as causative factors. Other symptoms may be urethral discharge, pyuria, hematuria, and frequent urination. Congenital strictures of large caliber are rather elusive and unless suspected will often be overlooked.

As previously stated, hernia is more frequent in boys with urethral obstructions, such as a small meatus and deeper congenital constrictions which require a straining effort to void. The patient is unaware of the strain required to empty the bladder until the obstruction is relieved; he then notices the difference in the effort required to void. A pin-point meatus should be incised in both boys and men, especially where there are any urinary or sexual disturbances. Furthermore, the presence of congenital urethral strictures of small caliber should receive appropriate treatment. Large strictures afford no clinical criteria which permit rules for their management. Undoubtedly, however, the maximum service to the individuals so affected will not be rendered if dilatation is omitted until such outstanding symptoms as retention, pyuria, urethritis, hematuria, frequent urination, excessive masturbation, unusual sexual desire or other affections arise and require treatment.

Diagnosis. When there is no previous history of inflammation, trauma, or other injury, urethral obstructions are designated as congenital strictures. It is usually impossible to differentiate between congenital narrowings which have been rendered evident by inflammatory changes or trauma and acquired strictures. Such coexistent affections, indeed, are not infrequent. Occasionally we see patients who tolerate well the dilatation of urethral strictures up to a certain point and beyond this the pain and reactions become worse than are usual in acquired strictures. A very large percentage of patients with non-specific urethritis and deep urethral irritation, and many with sexual disturbances will be greatly benefited or cured by dilatation of urethral strictures, even when of large caliber. *Urethral strictures are constantly being overlooked as causative factors of non-specific urethritis.* The rule " when in doubt dilate " will be well rewarded if followed as a routine. Much benefit often is obtained by the use of sounds when no strictures are present. Congenital strictures of babies should be differentiated from obstructions due to valves. In the latter condition, instruments may be passed into the bladder without difficulty.

Prognosis. In infants and young children, serious damage is usually done to the upper urinary tract before the congenital stricture is recognized. As previously stated, congenital strictures are not composed of fibrous tissue and, when incised or dilated, they do not show the same tendency to contract as do acquired constrictions. Congenital strictures, however, may or may not respond well to treatment by gradual dilatation. If they require urethrotomy and if they are followed subsequently with dilatations to prevent the incised areas from healing until the mucosa covers them, the result is likely to be more lasting than in acquired strictures, the reason being that in the former the scar tissue does not surround the urethra but is limited to the segment incised. Tight congenital strictures of the deep urethra usually require operation.

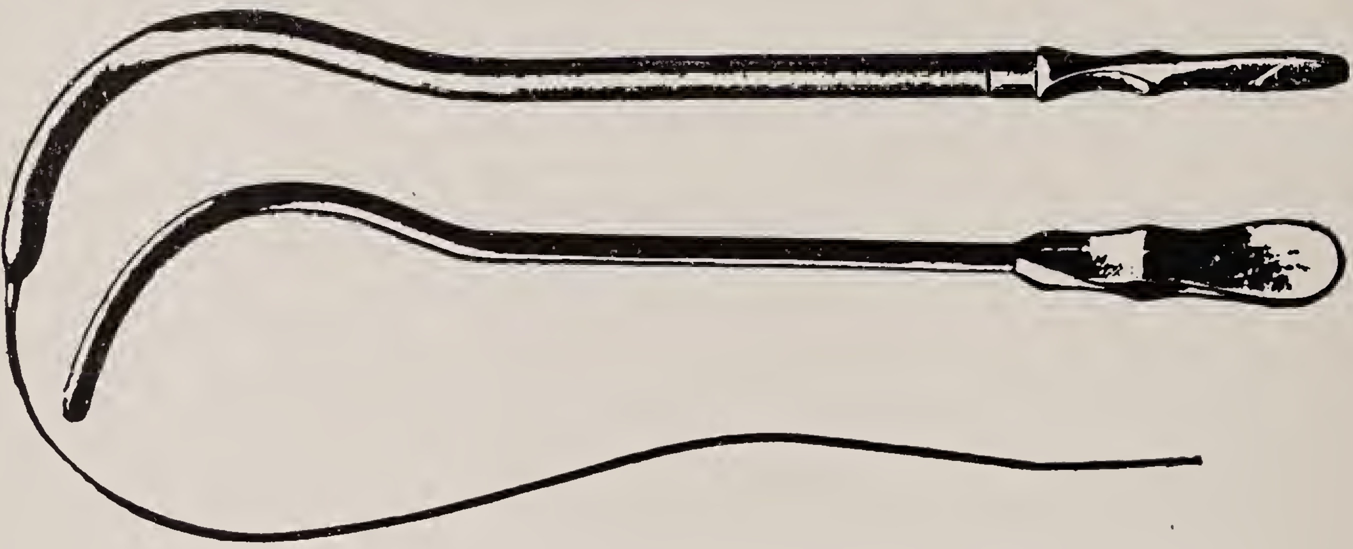

FIG. 29. Benique sound, with and without filiform guide.

Rapid dilatation of congenital strictures results in damage which is repaired with fibrous tissue and thereby adds to the obstruction the characteristics of an acquired stricture. This indicates the advisability of gradual dilatation, with emphasis on *gradual*, or perhaps the early incision of the stricture if the progress with dilatation appears to be unsatisfactory.

The prognosis of strictures varies largely with the duration and caliber of the constrictions; with the degree of cystitis, pyelitis, and pyelonephritis; with false passages; with extravasation of urine, fistulas and diverticula; and with the permeability of the urethra. The social condition of the patient, the previous attempts to cure the stricture, the complications and the kind of treatment indicated, are also features to be considered in making a prognosis.

Strictures of recent development, which permit gradual dilatation, usually respond well. Patients requiring external urethrotomy, in whom instruments can be passed into the bladder, afford a more favorable prognosis than do those with impassable strictures. Strictures with extravasation of urine are always grave conditions and require immediate operation.

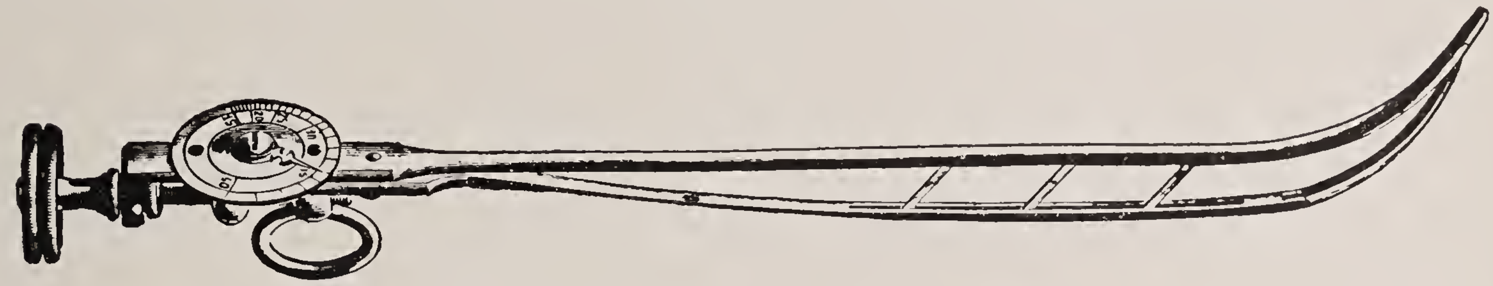

FIG. 30. Oberlaender urethral dilator.

The minor symptoms and affections caused by stricture, such as persistent urethral discharge, frequent urination, and sexual disturbances, usually disappear promptly when the constrictions are dilated. All strictures show a tendency to recontract, even when dilated or incised, and the rate of this contraction varies widely. Fistulous tracts, caused by false passages, abscesses and extravasation of urine, often heal after the urethral canal is restored to normal, but not so long as the strictures are allowed to remain of small caliber. Bladder stones are more likely to form in patients who have strictures than in individuals with normal urethral canals. Retention of urine or residual urine increases the danger, especially if internal urethrotomy is performed. The prognosis is always better when preliminary preparation with retention catheters or filiforms is possible. In the majority of instances, retention catheters or small bougies will often be followed by enough improvement to permit gradual dilatation, thereby removing the operative dangers.

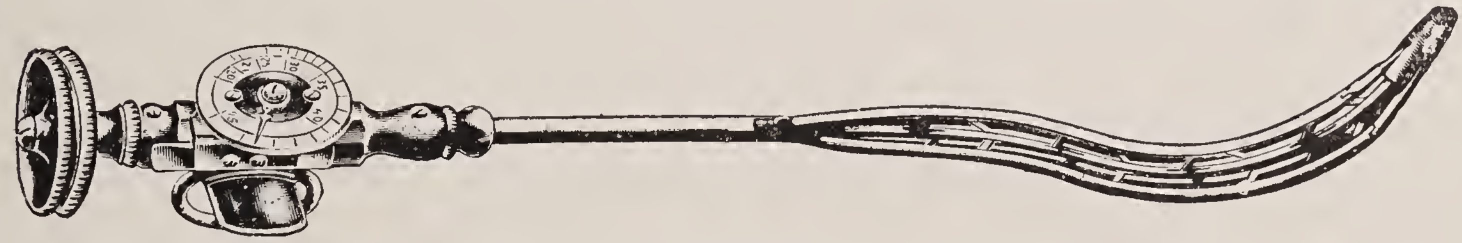

FIG. 31. Kollmann urethral dilator, Benique curve.

Urinary sepsis and pyelonephritis may improve with surprising rapidity after the urethral obstruction has been relieved, whatever the method employed.

Treatment of acquired urethral strictures. Strictures may be prevented to some extent by the proper treatment of gonorrhea. Regardless of the origin of acquired strictures, the treatment is practically the same. Definite deposits of fibrous tissue in the urethra are permanent; treatment may provide an adequate caliber, but the tendency to contract will persist. Gentleness and cleanliness are extremely desirable. Novocaine, in a one per cent. solution, injected into the urethra and retained for 5 minutes before the passage of instruments, produces sufficient analgesia to lessen the fear which might cause the patient to neglect the dilatations.

Gradual dilatation. In the management of urethral strictures, when existing conditions permit its use, gradual dilatation is the method of choice. The instruments required are: whalebone filiforms, small woven bougies, whip bougies, catheters, sounds, and Kollmann dilators. It is not possible to say in advance what type instrument can be made to pass urethral constrictions of small caliber or those associated with complications such as false passages, abscesses, fistulous tracts, and extravasation of urine. For strictures of large caliber, conical steel sounds and the Kollmann dilator are employed; the latter is preferable to sounds above 28 or 30 F. The dilatations are repeated at intervals varying with the tightness of the stricture and with the severity of the reactions which follow. Inflammation produced by the dilatation should be allowed to subside before further stretching is employed. Urethral irrigations between dilatations shorten the duration of the inflammatory reactions; unless the urine becomes cloudy after the passage of sounds or dilators, irrigations are unnecessary.

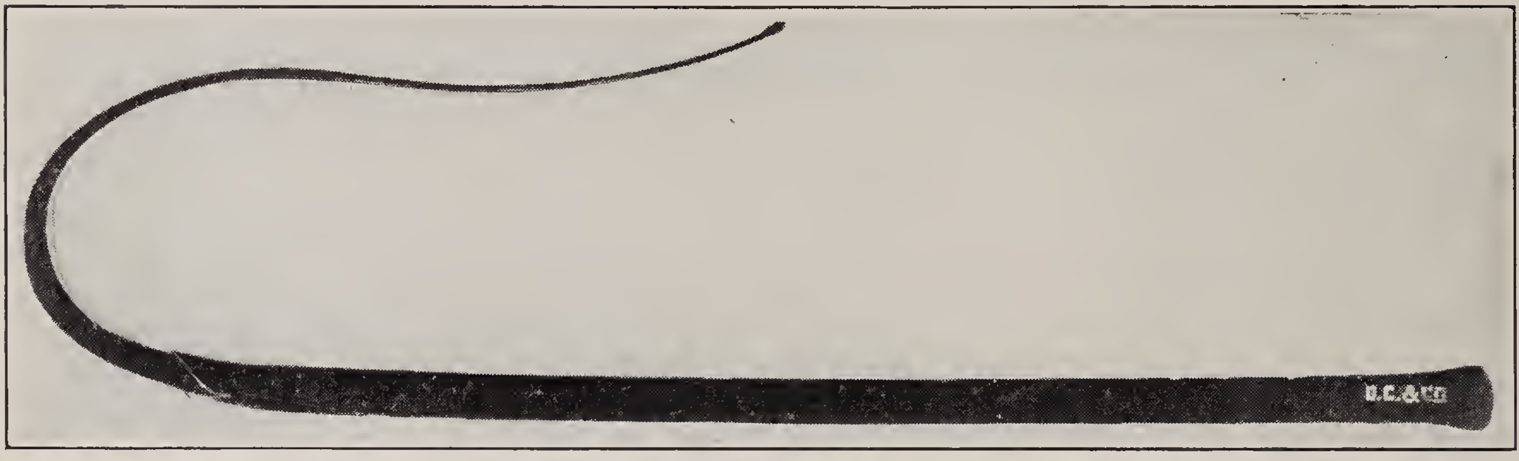

FIG. 32. Phillip's one-piece bougie.

Over-dilatation is always harmful. Dilators of the Kollmann type should be of the Benique curve, and the entire urethra should be dilated. With Kollmann dilators, strictures can be stretched to a much larger caliber than with sounds; since all acquired constrictions show a tendency to contract, the extent of dilatation should be well in excess of what would be considered the normal caliber of the urethra. The duration of the benefit derived from dilatation of strictures is largely in proportion to the caliber ultimately obtained. The dilatation of strictures always should be gradual. At no treatment should a stricture be stretched to a point where the trauma produced will be sufficient to require repair by scar tissue. The dilatation should produce only a tension- or pressure-necrosis of the most constricting tissues, with absorption, not repair by a further deposit of fibrous tissue. After the caliber of a stricture is ascertained, the dilatation of more than one number on the French scale is not advisable; later the length of intervals between treatments may be increased. The duration of treatment varies with the degree and time of subsequent contraction of the stricture. Not infrequently it will be necessary to carry the dilatations several times to the same number before being able to introduce larger sounds or to expand the Kollmann dilator to a higher reading.

Strictures of small caliber should be dilated with woven bougies, tapering or olive tipped, until the caliber of 18 or 22 F. is reached. The bougies with a core of lead or shot have the advantage that, when bent, the shape is maintained sufficiently to guide the point of the bougie along the roof of the urethra. The passage of bougies of this type, as well as of sounds, is facilitated by slight traction on the penis.

Filiform strictures. Strictures which have contracted to the filiform variety require more dexterity and judgment than do larger ones. The essential factor in the treatment of filiform strictures is to pass, if possible, a whalebone or woven filiform into the bladder; patience, adequate lubrication, not only of the instruments but also of the urethra, and a variety of filiforms may be required. The lumen of the urethra at the stricture is often eccentric, and instruments which are slightly bent at the end will pass more easily than will straight filiforms. When the filiform has been introduced into the bladder, the plan to be followed depends upon the tightness of the constrictions, the condition of the patient, and upon the complications — such as retention, infection, pyelonephritis — the renal function, abscesses, false passages, and extravasation of urine. Banks' tapering whalebone or Phillip's woven bougies may enable the surgeon to dilate the stricture sufficiently to permit the withdrawal of the instrument. If little difficulty has been experienced in passing the strictured areas, the filiform may be removed.

Filiforms are of several types: slender, straight, whalebone; tapering whalebone; woven, tapering, whip-like bougies; and woven filiforms with a screw for connection to larger sounds, woven bougies or catheters. Tunneled, grooved followers may be used with the slender filiform to guide the passage of the larger instruments through the stricture. After the filiform has passed the stricture, it may be obstructed by a pocket in the deeper urethra. Whether it has entered the bladder is determined by estimating the depth to which it has entered and by the ease with which it may be advanced. Whalebone filiforms may bend or break, and as guides, unless employed with gentleness, are not as safe as might be desired.

FIG. 33. Phillip's two-piece bougie with olive tip detachable male thread filiform.

Continuous dilatation. If there are false passages, if the stricture is difficult to pass, or if the constriction is tight, it is usually better to allow the filiform to remain in the urethra for several days, after which instruments of larger size are easier to pass; the usual gradual dilatation then may be continued. If desired, several small filiforms, the larger filiforms, or small catheters, may also be allowed to remain in the urethra for several days or weeks longer; the length of time must be governed by the existing conditions. The filiform character of a stricture by no means indicates that gradual dilatation cannot be followed successfully.

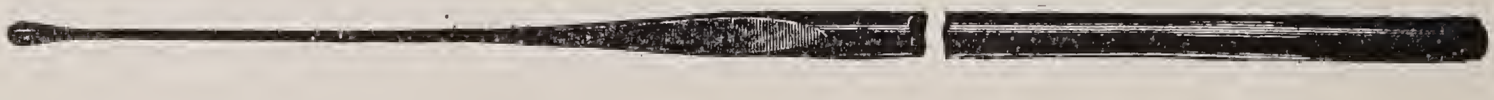

FIG. 34. Tapering whalebone filiform.

If complications such as extravasation of urine or extensive abscesses do not demand an operation, excellent results will follow the employment of retained filiforms and subsequent dilatation. Unless contraindicated, continuous dilatation is, without doubt, the best procedure; the immediate dangers are less than with urethrotomy and the ultimate results are better. Even in patients with retention, the urine will escape around the filiforms and in a few days the urine can be voided in a larger stream. Other filiforms then may be passed, and, after a few days or a week, these may be followed by a small catheter. Subsequently, gradual dilatation is employed in the usual manner. When there is extravasation of urine, this plan is nearly always contraindicated. With ordinary tight strictures, however, the results afforded will usually eliminate the necessity of operative measures. Formerly, the indwelling filiform, when passed after much difficulty, was often utilized only long enough to arrange the details of an operation; with many surgeons, urethrotomy now is em-

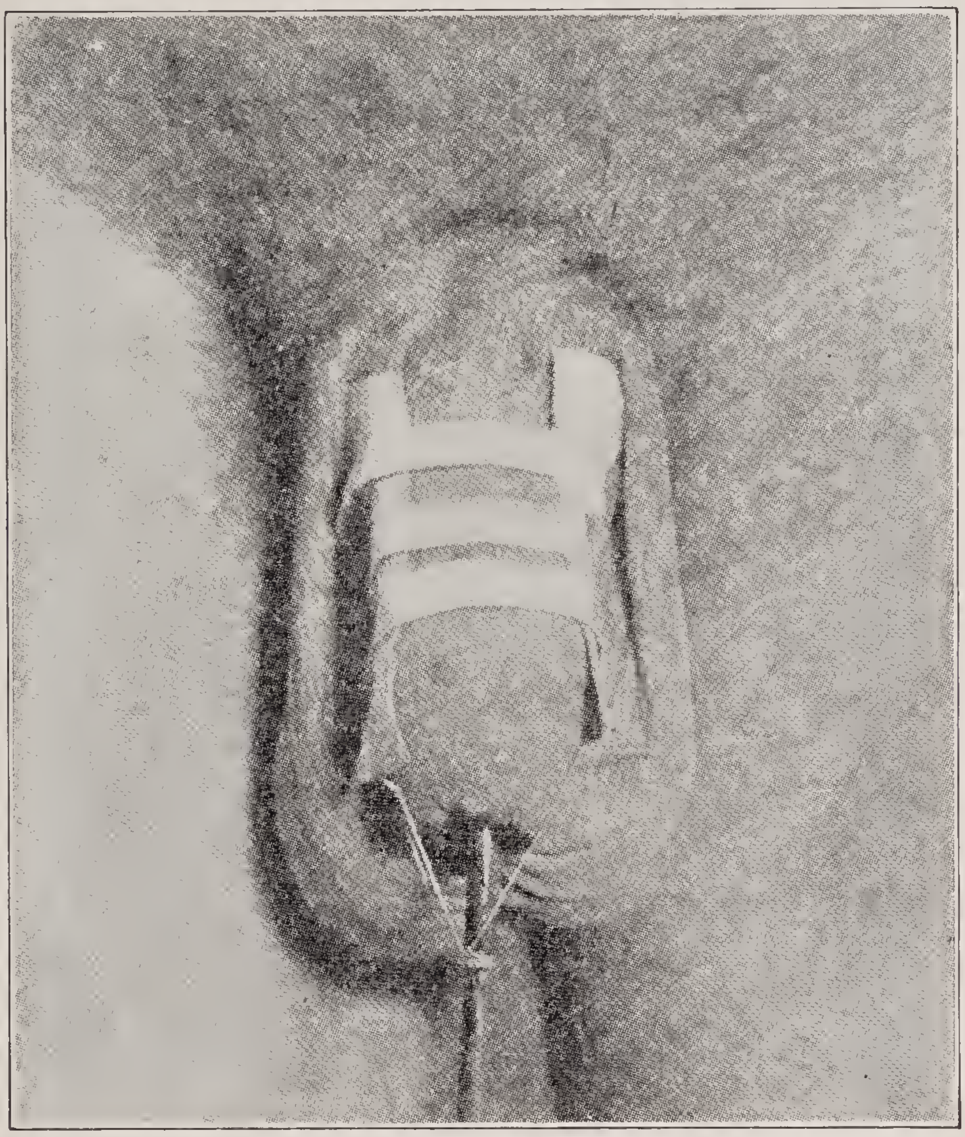

FIG. 35. Bougie tied in the urethra with a string. The adhesive plaster does not become wet with urine when the patient voids around the bougie.

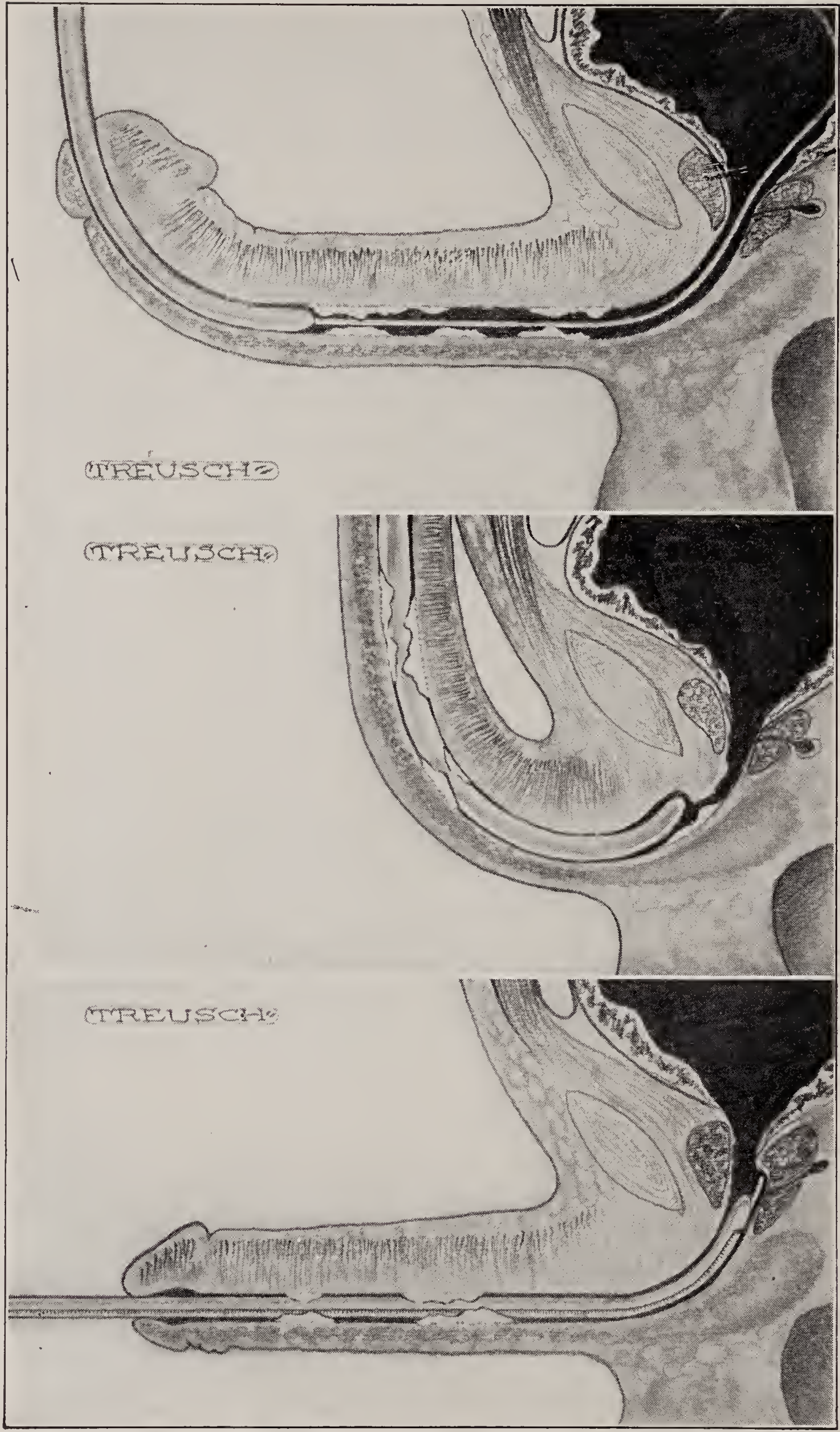

Fig. 36. Upper drawing shows Le Fort bougie following filiform through urethral strictures. Middle drawing shows tunneled sound passed to a stricture in the bulbous urethra. Lower picture shows tunneled sound and filiform passed as far as the prostatic urethra. Vol. 3. 1139.

ployed in an exceedingly small percentage of cases. The passage of instruments after external perineal urethrotomy is considerably more difficult than if the plan above described is followed. When dilatation alone is used, the patient is impressed with its value as well as with the necessity of its continuation and, as a rule, will report for treatment with greater regularity than if urethrotomy is performed. Urethrotomy is regarded, too often, as a curative factor instead of an assisting measure.

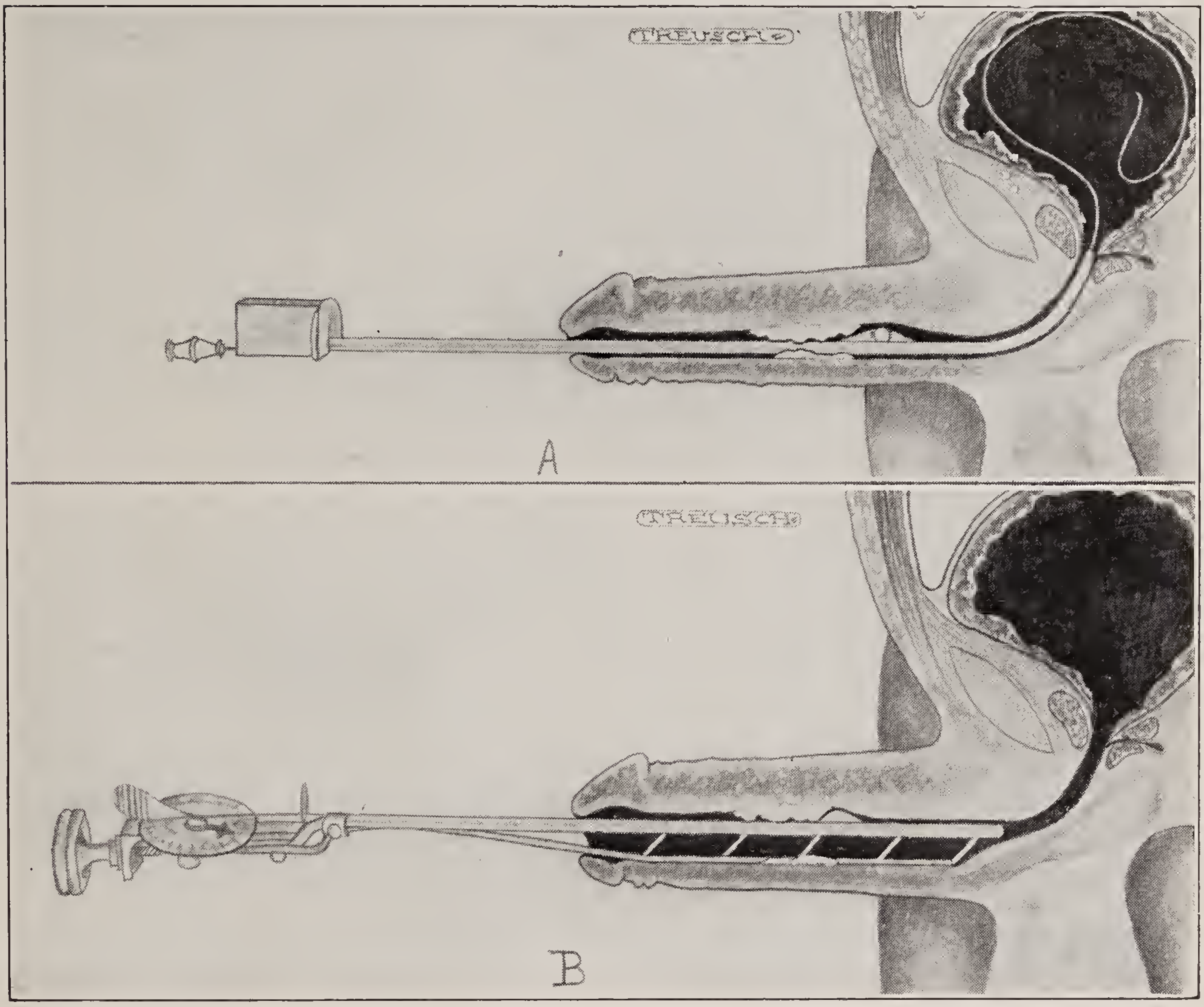

FIG. 37. A. Maisonneuve urethrotome incising urethral strictures from before backward. B. Internal urethrotomy with Otis urethrotome.

Impassable strictures. Not until every reasonable effort repeatedly has been made should a stricture be regarded as impassable. An adequate variety of filiforms and other urethral instruments should be available; the urethra should be filled with novocaine in a one per cent. solution for 5 minutes, then with lubricating oil (mineral oil); filiforms should be passed until perhaps 8 or 10 have been introduced as deep as possible; one after another is then advanced and manipulated in the hope that the narrowed urethra may be entered and a filiform passed into the bladder. As previously mentioned, instruments slightly curved or bent near the distal end are more likely to pass the eccentric opening of small strictures than are the straight filiforms or those with corkscrew shapes.

Force is never advisable in passing, or attempting to pass, urethral instruments of any kind.

In case the stricture cannot be passed with a dilating instrument, if the patient can void, or if there are no complications requiring operation, the attempt to enter the bladder with filiforms may be postponed for 24 hours, during which time rest and hot baths are advised. If the bladder is distended and immediate relief is necessary, the most satisfactory temporary relief is suprapubic puncture with a small trocar. This may be repeated a number of times without danger. Care should be taken, of course, not to insert the trocar so high that it will enter the peritoneal cavity.

Not infrequently the relief afforded by suprapubic puncture may permit the passage of filiforms that previously could not be introduced.

Complications sometimes resulting from urethral dilatation. *Urethral chills and fever.* Urethral instrumentation of any kind may be followed by more or less severe chills and fever. This occurrence is more likely to arise when the deep urethra is entered than if the instruments are employed in the anterior urethra only.

Divergent opinions are held as to the etiology of urethral chills and fever. Some urologists assert that the affection cannot be ascribed to urinary absorption; others emphasize this factor as the essential cause. These urethral disturbances are sometimes confused with, or are coexistent with, septicemia, toxemia, and uremia. The attacks do not vary necessarily with the degree of trauma produced in the urethra. The symptoms range from a slight nervous chill, followed by malaise and fever, to profound collapse or surgical shock, with depression, anuria, uremic symptoms and high fever. Extensive herpes labialis occurs not infrequently with urethral chills and fever.

Precautions are advisable for patients with scanty or highly acid urine, and especially if casts and albumin are present. The urine should be rendered alkaline, and, if the patient is able to void, liquids should be taken freely for several days to flush the urinary tract. The bowels should also receive proper attention. If there is nausea, vomiting, or hiccough, glucose should be administered subcutaneously or intravenously. If the blood urea is above normal, still greater care should be taken with the preliminary treatment. Sulfanilamide, pyridium or urotropin should be administered according to conditions to be met. It should be remembered that patients with poor renal function eliminate sulfanilamide slowly and may acquire a high concentration in the blood when taking only relatively small doses. In consequence they may develop serious toxic reactions early. If anuria and infection are both feared, 40 to 60 grains of sulfanilamide may be administered in lactate Ringer solution subcutaneously; glucose, 5 per cent., should be added if supportive nourishment is indicated. Unfortunately, the urgency of the symptoms may preclude adequate preliminary measures.

In case of hiccough, nausea, vomiting and gaseous distention of the intestinal tract, life often can be saved by the following plan: 1, omit all foods and liquids by mouth; 2, glucose (5%) in normal saline solution, subcutaneously or slowly intravenously; 3, saline enemas as needed; 4, hot turpentine stupes to abdomen constantly. *If this treatment is not effective within twenty-four hours:* 5, the Levine tube is passed through the nose, down the throat into the stomach and allowed to drain its contents. (The outer end of the tube is connected to a rubber tube leading to the bottom of a receptacle. The patient is allowed to drink water freely, which flows out of the stomach by syphonage). 6, Mild purgatives and laxatives are cautiously employed; 7, drastic purgatives are used only after careful consideration: 8, glucose in lactate Ringer solution or saline solution is continued subcutaneously or intravenously; 9, if required, appropriate amounts of sulfanilamide may be added to these solutions but *only when to be given subcutaneously.*

Epididymitis and prostatitis. Inflammation of the epididymis and the prostate gland is caused, not infrequently, by urethral dilatations.

Urethrotomy. *Choice of operations.* Operations for urethral strictures are limited to the constrictions in which dilatation methods are inadvisable or fail. Internal urethrotomy is employed for strictures in the anterior urethra but never for impassable strictures, nor for those in the membranous and deep urethra. For the latter group of urethral constrictions, when the dilatations fail or when complications require operative measures, external perineal urethrotomy should be employed.

Dense, tight, palpable constrictions in the anterior urethra which yield poorly to dilatations, or contract promptly, and those with complications, are the strictures which may require internal urethrotomy. The fibrous deposit, of course, remains after the incision, but the scar-tissue formation at the incised point may be less extensive and more dilatable than was the original stricture. Internal urethrotomy is not infrequently employed with external urethrotomy. The complications which may require external urethrotomy are extravasation of urine, extensive and persistent fistulas, and, less frequently, periurethral inflammation and abscesses.

Preliminary preparation for urethrotomy. Owing to the danger of anuria and infection following urethrotomy, internal and external, preliminary preparation should be employed, when feasible, to obtain the maximum renal function and to control infection. A study of the blood chemistry, the phthalein test, and urinary findings, afford valuable data as to the time to operate, as well as concerning the prognosis. Reference already has been made to the need of alkalies when anuria is feared, or of sulfanilamide or other urinary antiseptics when infection seems more likely to occur, and to the necessity of forced fluids in both cases. The gradual withdrawal of residual urine, when the amount is large, requires the same care that would be exercised if prostatic hypertrophy were the cause of the urinary obstruction.

Urohepatic syndrome. Douste-Blazy and Dourmashkin emphasize the danger of urethral shock in patients with hepatic disease. The dilatation of urethral stricture, with coexisting hepatic disease, especially if the renal function is inadequate, is likely to be followed by extremely dangerous symptoms. In order to know when to exercise great care in performing urethral manipulations, the possibility of such a result emphasizes the importance of a thorough general examination to determine the existence of hepatic disturbances, as well as inadequate kidney function, in patients with obstructive lesions of the lower genito-urinary tract.

Impassability of the strictures or the extravasation of urine may prevent the desired preliminary treatment.

Anesthetics. Evipal, intravenously, sacral anesthesia, low spinal or gas oxygen may be employed according to the requirements of the patient or the preference of the operator.

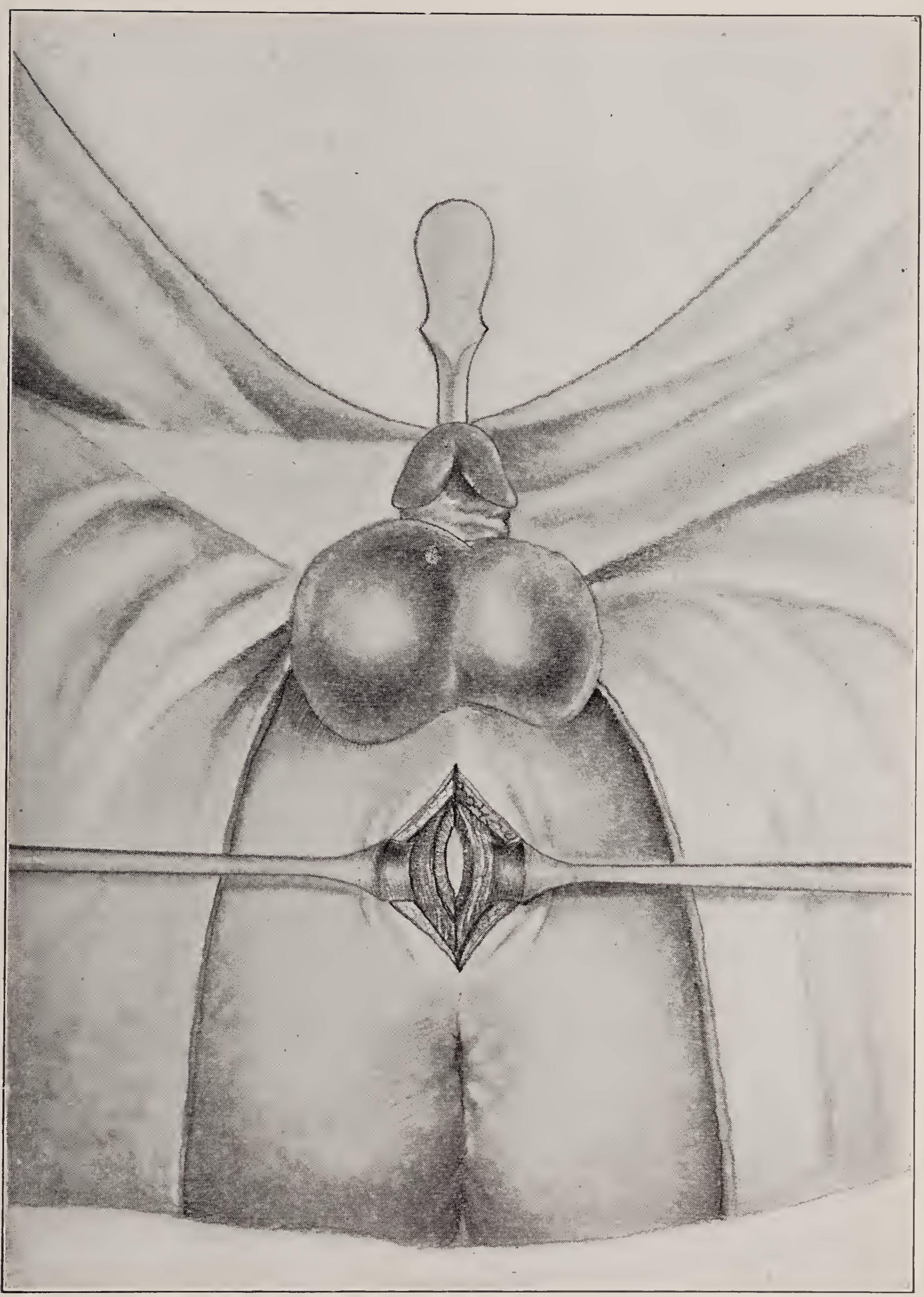

Fig. 38. External urethrotomy, showing sound through a longitudinal incision into the urethra.

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Internal urethrotomy. The patient should be in a hospital, and adequate preparatory treatment should be administered.

For strictures of large caliber, the Otis urethrotome is employed, the incisions being made from the deeper part forward.

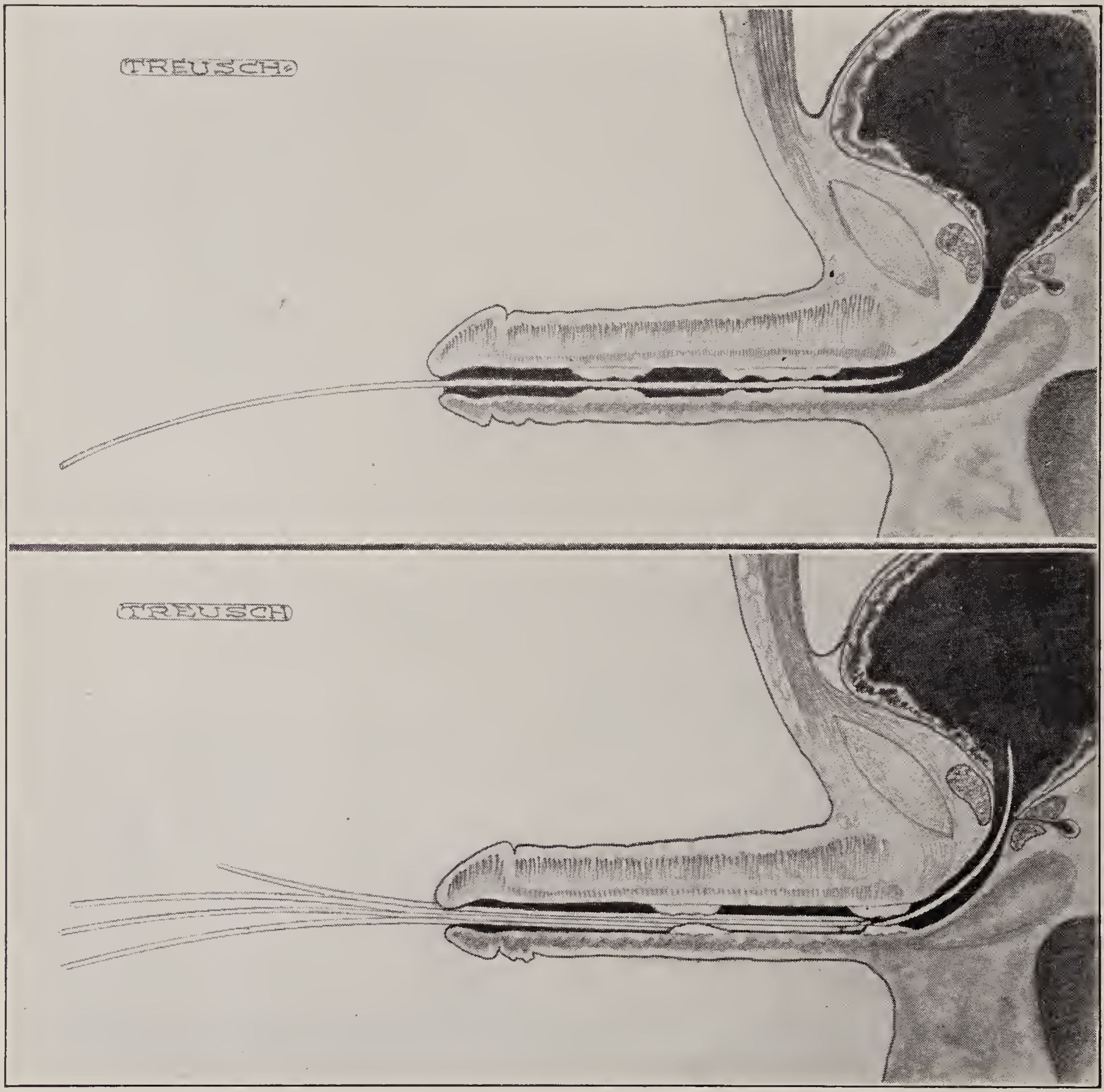

Fig. 39. Filiforms in urethra. One is shown introduced into bladder. Whalebone filiform introduced through urethral strictures.

For strictures of small caliber the Maisonneuve should be used; this instrument cuts from the anterior part backward.

After the urethra is anesthetized, the Otis urethrotome is introduced, the cutting part upward, until its tip is about an inch beyond the stricture; the urethra is dilated until the tension is

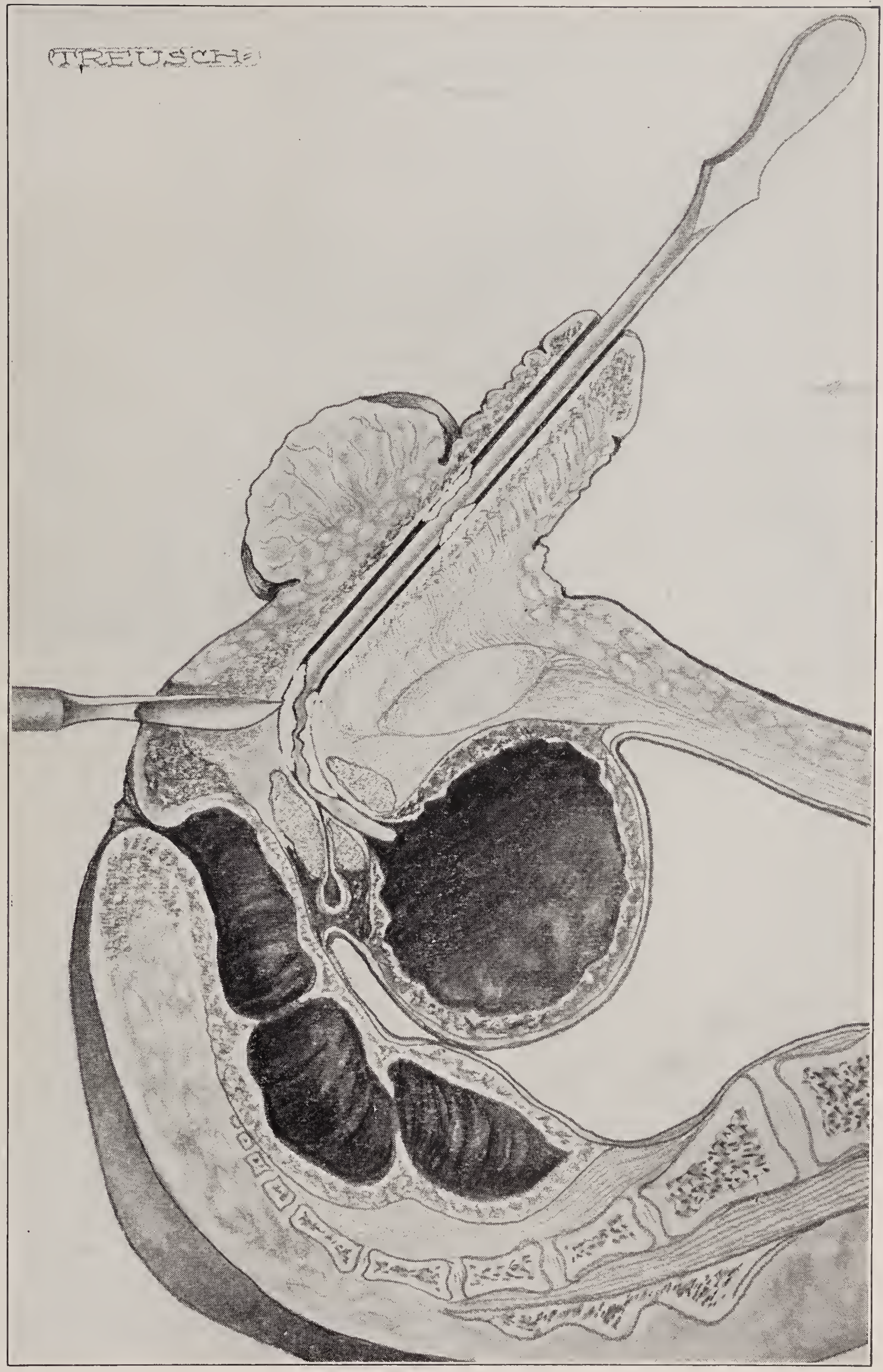

FIG. 40. External urethrotomy.

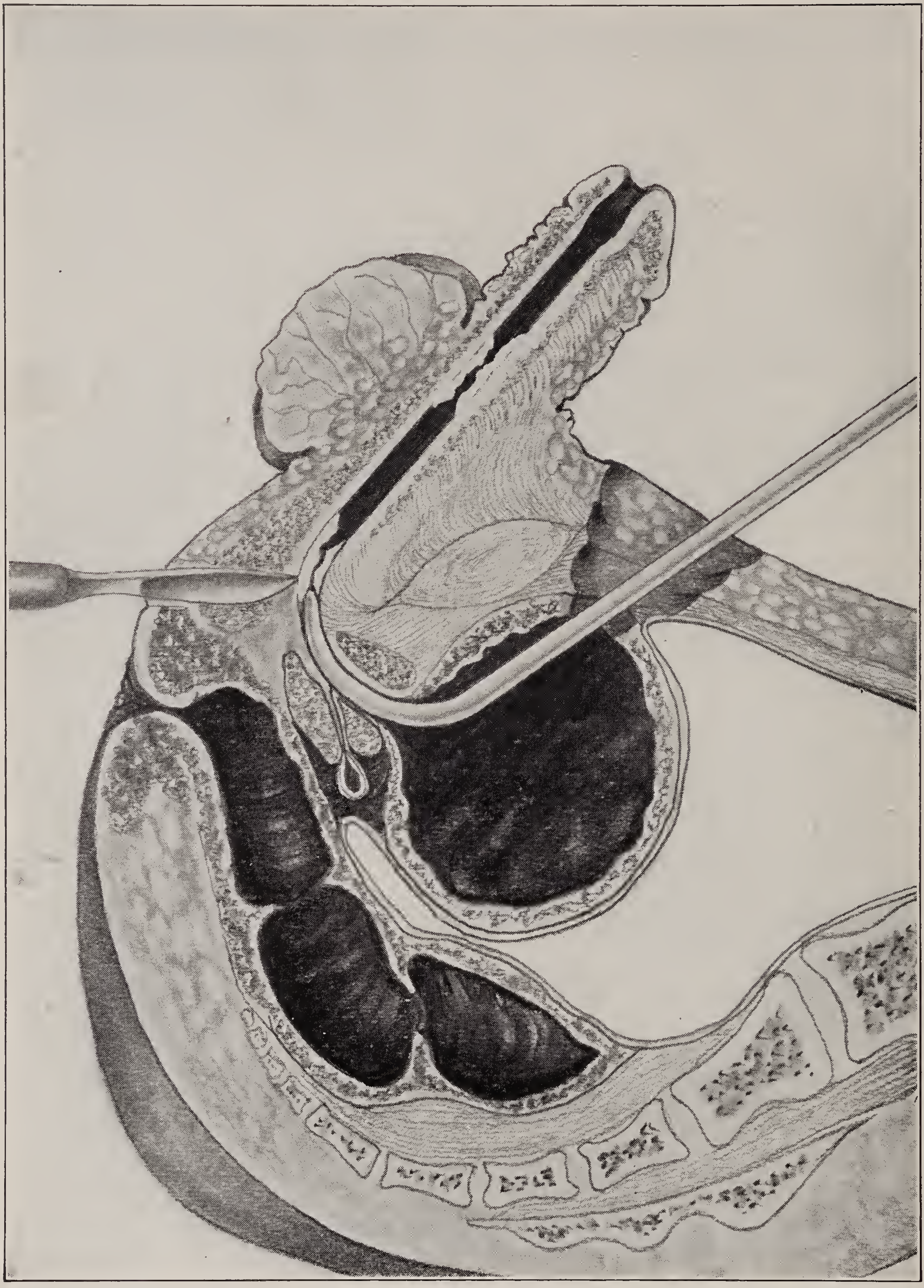

FIG. 41. External urethrotomy with a sound passed through suprapubic incision to identify the deep urethra. This method is safer than a prolonged search for the deep urethra in case of abscesses, urinary extravasation or other causes which make it difficult to enter the bladder through the perineal incision. VOL. 3. 1139.

felt. The handle of the knife is drawn up far enough to cut the stricture and is then pushed back until the blade is in its hiding place. Other strictures should be cut in the same manner. After further dilatation, the procedure is repeated until a caliber of 32 F. is reached. Bulbous bougies are employed to determine if obstructed points are left. The urethrotome may be introduced again and the cutting repeated until the desired caliber is obtained. The tendency to chills and fever subsequent to the operation is reduced by the preliminary treatment and by limiting the operative procedure to the anterior urethra.

Tight strictures in the anterior urethra may be cut with the Maisonneuve urethrotome. The bladder should be full of urine or irrigating solution. The filiform bougie is passed into the bladder and the slotted guide for the blade is screwed to the filiform. The instrument is then introduced. An assistant holds the penis upright while the surgeon inserts the knife into the groove and on down the canal, incising the strictures on the roof of the urethra to 18 or 20 F. Bulbs are passed and the location of obstructions are noted. The Otis urethrotome is then used for further incisions. As already stated, external urethrotomy is frequently performed first, cutting the deep strictures, and then using the urethrotomes for the strictures in the anterior urethra.

The treatment after internal urethrotomy is concerned chiefly with the administration of urinary antiseptics and in forcing fluids. The catheter should be removed in 4 or 5 days. Thereafter urethral sounds should be introduced every 4 or 5 days to maintain the caliber gained by the operation. The intervals between the passage of sounds is gradually increased. The Kollmann dilator may be employed with advantage at times but should always be used with caution lest overdilatation be done.

External urethrotomy. External urethrotomy is indicated for strictures in the bulbous, membranous, or prostatic urethra when the character of the constriction or the complications prevent the successful employment of gradual dilatation.

Preparation of the patient for external urethrotomy. When external urethrotomy is needed, the condition of the patient is more serious than in those permitting internal urethrotomy; greater care is required, therefore, in the preliminary treatment, except when there is extravasation of urine. If the latter supervenes, the operation becomes at once an emergency one.

First in importance in the preparatory treatment is a painstaking effort to introduce an instrument of some kind through the urethra into the bladder. When possible, a metallic instrument, such as a grooved or plain sound, is preferable to a filiform. If not even a filiform can be introduced, but the patient is able to void, hot baths, milk diet, rest, and alkaline drinks should be employed for a few days; such treatment may then permit the passage of small bougies or filiforms.

If the patient is unable to urinate and instruments cannot be introduced, the suprapubic space should be punctured and the bladder partly or completely emptied, as the history and conditions indicate. When the accumulation of urine has been gradual and there is reason to believe that the renal function has been seriously impaired, not more than a pint of urine should be drawn by catheter, or aspirated, at first. The procedure should be repeated every 6 hours until the bladder is emptied. At the time of the operation, however, the bladder should be full either of urine or a sterile solution, and the suprapubic space should be prepared for cystotomy. The instruments should be looked over and care taken to have available everything likely to be needed in case difficulty is experienced in entering the deep urethra and bladder.

Position of the patient. If an instrument has been introduced through the urethra into the bladder, the patient should be placed at once in the lithotomy position with the buttocks at the end of the table, the knees separated and the thighs flexed. The patient should not lie on the table at an angle, nor should one side be higher than the other. The penis and scrotum, as well as the suprapubic and perineal regions, should be sterilized with alcohol-acetone-mercurochrome or picric acid solution.

External perineal urethrotomy with a guide. External perineal urethrotomy, as already emphasized, is a safer, easier operation if a metallic guide has been introduced, and every reasonable effort should be made to pass such an instrument. The guide should be held exactly in the mid-line with the convex portion presenting in the perineum. The scrotum is raised and an incision is made in the median line of the perineum from a point just behind the scrotum to about one inch from the anus. The incision is deepened, the bulb freed, the guide is located in or back of the bulb and the urethra is incised at the point desired for about 2 or 3 centimeters. The point of the knife is then carried along the groove toward the deep urethra to the extent required. The urethra anterior to the incision is then incised with the point of the knife in the

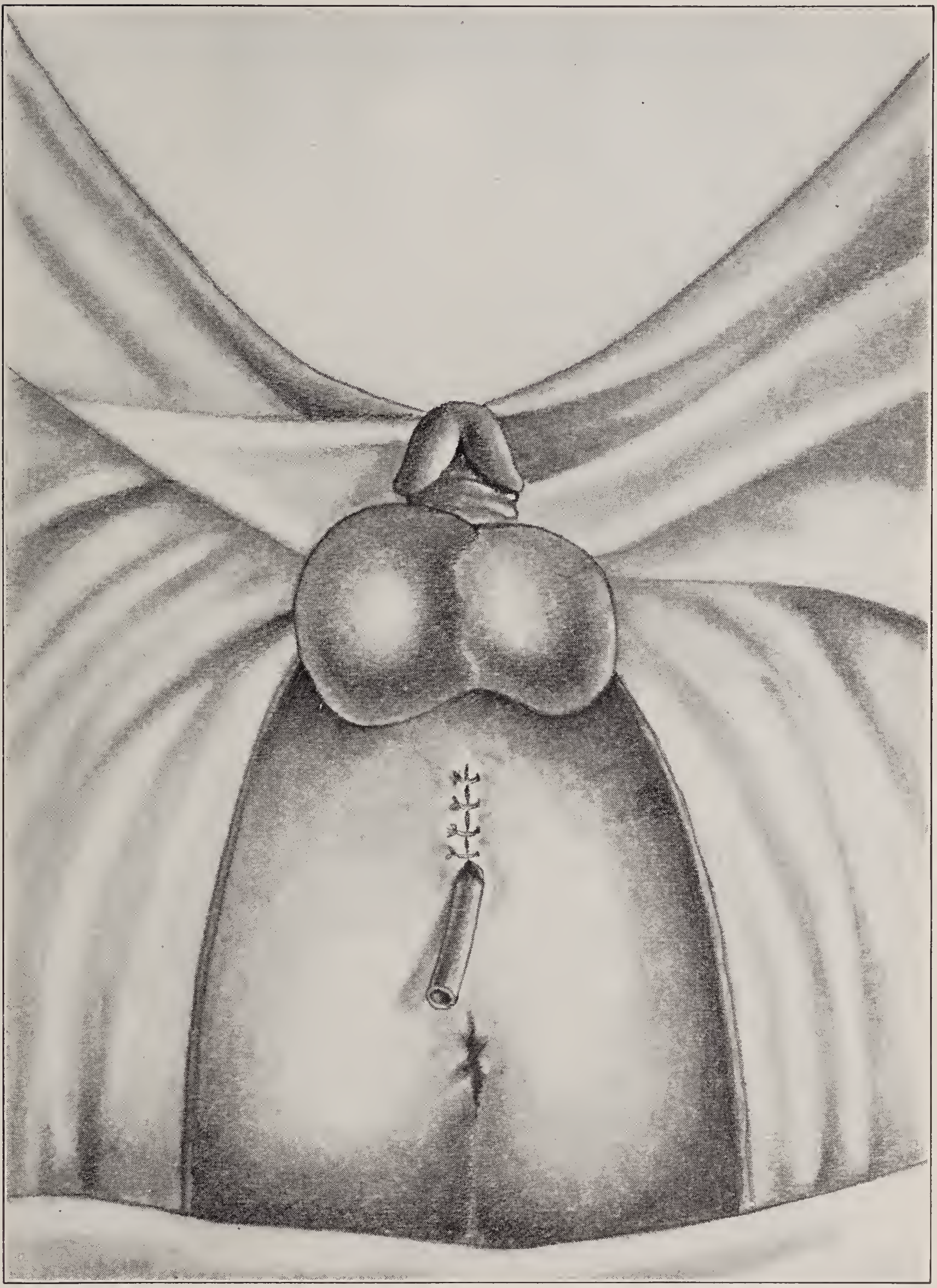

FIG. 42. Perineal drainage tube after external urethrotomy.

groove. With both of these incisions the knife should be held nearly parallel with the urethral instrument. Further incision of the urethra posteriorly may be made with a blunt-pointed, thin-bladed knife. A grooved perineal director may be passed into the deep urethra and bladder, the guide removed and the strictured area further incised through the grooved director. The finger may be inserted into the bladder and the peculiar feel of the internal sphincter noted.

Greater care is required when only the filiform has been passed into the bladder. The urethra is freed to a greater extent and a larger incision, exposing the guide, is made in the urethra. Care should be taken not to cut the filiform. If the stricture has been incised, the tunneled guide then may pass on into the bladder; if it does not, the filiform is held, with a pair of forceps, below the end of the guide which is slightly withdrawn, a small grooved director is passed along the filiform into the deep urethra and bladder, and the urethrotomy completed as above described.

When even the filiform cannot be introduced into the bladder, methylene blue, 0.5 per cent. solution, is injected into the urethra and milked into the deep urethra and bladder; the excess is washed out of the anterior urethra with salt solution. A sound is passed as far as possible into the urethra, which is then incised at the distal end of the sound. A grooved probe is inserted as far as possible into the urethra and the incision along its floor is lengthened. By probes or filiforms the orifice of the strictured urethra is sought. A vertical incision in the mid-perineal line may split the strictured urethra in the region of the bulb or deeper, and permit the passage of a probe into the bladder. A rotary, dilating, boring effort may be made with the forefinger carried along the roof of the urethra, hoping to enter the prostatic portion of the canal and bladder; if not successful, various expedients are available. Keyes suggests transverse incision to bring into view the blue mucosa of the urethra and from this point to introduce probes or filiforms. Young advises exposure of the apex of the prostate, incision into the membranous urethra, inserting a guide and cutting the urethra from behind forward. Rather than prolong the search, it is safer to do a suprapubic cystotomy and pass a sound from above through the internal sphincter into the deep urethra and on out into the perineum; the identification and incision of the urethra then is easy.

Drainage. After completing the urethrotomy, the decision as to

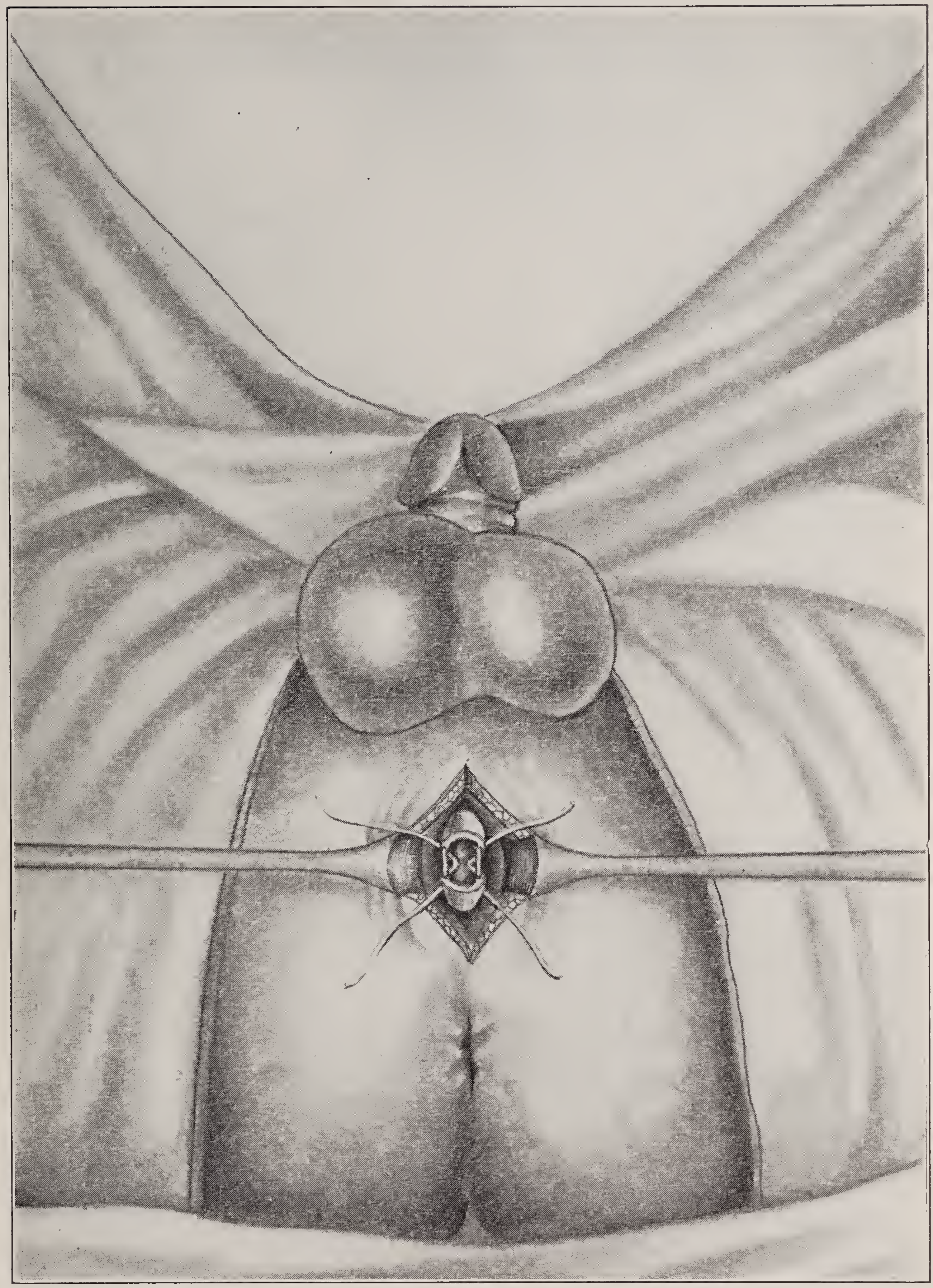

FIG. 43. Incomplete urethrectomy.

whether an indwelling catheter or merely a perineal tube is to be employed for drainage depends upon the location of the strictures, the amount of urethral and periurethral infection, false passages, extent of the renal involvement, and upon the condition of the patient.

Both plans of drainage have advantages and disadvantages. The perineal tube is better for patients with extensive infection and seriously damaged kidneys; the subsequent passage of sounds is more difficult, however, than if the indwelling catheter be employed. For strictures anterior to the bulb and for patients with good kidneys and not extensive infection, or periurethral abscesses, the catheter may be used. Regardless of the drainage utilized, the bladder should be washed with a mercurochrome or boric acid solution until it is free of clots and blood. The perineal tube is adjusted until it projects only a short distance into the bladder. It should be held in position with a fixation stitch through the skin, preferably on each side.

Packing the urethra around the drainage tube to stop bleeding should not be employed, as it is likely to start hemorrhage a few days later when the gauze is removed.

Closure. The extent of closure of both the incised urethra, where the caliber permits, and the skin, depends largely upon the amount of infection. The bulbous urethra may be partly drawn together with catgut. The urethral mucosa will soon cover the raw surfaces. If the urethra has been severed transversely, the cut ends should be approximated at the roof with catgut.

The skin and perineal tissues should be brought together with 3 or 4 chromic catgut stitches; space should be left for a small cigarette drain. Abscesses and tissues extravasated with urine should be incised freely and drained.

False passages should be opened into the urethra, if feasible, or drained externally, as seems indicated.

Treatment after external perineal urethrotomy. By ligation of bleeding vessels or pressure over the bulb at the time of the operation, serious hemorrhage is prevented. The bladder should be irrigated once a day or oftener, if required, to keep the tubes or catheters open. Liquids and citrus fruit juices should be taken freely. If there is even a tendency to suppression of urine, glucose should be given subcutaneously or intravenously, as required. The drainage tubes should be removed in 4 or 5 days and sounds passed a few days later, and for a while thereafter every 4 or 5 days;

later, the Kollmann dilator may be used instead of the sounds. The time between treatments is lengthened as the extent of the dilatations is increased. The subsequent examinations and dilatations are the same as those employed for stricture treated by gradual dilatation.

Excision of strictures. Extensive resections, plastic operations, and end-to-end anastomoses for urethral strictures are rarely advisable or necessary. For a certain number of dense, fibrous, uncomplicated strictures that extend for only a limited distance along the urethra, and have contracted promptly after dilatation, operations other than incision may be considered.

Cabot utilized the Heinecke principle, dividing the stricture on the floor of the urethra by a longitudinal incision and closing it transversely, thereby enlarging the lumen at the constricted point. Cabot's operation is applicable only to comparatively narrow strictures. The technic is as follows: A sound is passed; the urethra is dissected from the surrounding tissues; the area of the stricture, and for a short distance in front and behind it, is incised. The opening is sutured transversely with fine catgut; the sutures are not tied, however, until all are placed. The lateral sutures are tied first, then the central ones that approximate the anterior and posterior ends of the original incision. Drainage is provided by a small indwelling catheter.

For strictures accompanied by extensive cicatricial tissue, Young advocates the excision of the fibrous mass without the excision of the mucous membrane in the following manner: "After a good wide exposure has been obtained, and the strictured area has been widely divided, the extensive mass of scar tissue should be carefully excised on each side, leaving intact the strip of mucous membrane which intervenes between the normal anterior and posterior portions of the urethra. This excision will leave a cavity which is surrounded by the more or less cavernous and muscular tissues of the bulbous urethra. A large catheter is then passed into the bladder through the urethra and the soft tissues are drawn together, fairly tight, around the catheter with a continous plain catgut suture. The perineal fascia is approximated by a similar line of suture, and the skin and subcutaneous tissues are closed completely, except at the anterior angle, where a small superficial antiseptic pack is inserted for drainage of the skin wound. The catheter emerging from the meatus is fastened in place and mild antiseptic treatment of the bladder, several times a day, is carried out to prevent infection. The catheter is left in place for about a week unless suppuration or irritation requires earlier removal. Thereafter urethral dilatation with sounds should be carried out, beginning about the twelfth day and repeated once every 4 or 5 days until cicatrization is completed and a normal, large urethra is insured."

Urethrostomy. In rare instances the fibrous deposit in the penis following extensive abscesses and extravasation of urine may make it desirable to perform perineal urethrostomy to provide a permanent outlet for urine posterior to urethral constrictions. As a rule it is preferable to establish the opening in the perineum, midway between the scrotum and the anus. The incision is carried to the urethra, which is dissected free, severed transversely, and then sutured to the skin so as to afford a large mucocutaneous fistula through which all of the urine flows. Catheter drainage is unnecessary. Unless the patient is fat, perineal urethrostomy is not difficult or dangerous and, when the circumstances and condition of the patient are such that the usual treatment for dense urethral strictures cannot be employed, may be life saving.

Urethrostomy is sometimes employed as a preliminary step in operations for hypospadias to prevent infection and soiling of the operative field, although continuous antiseptic bladder drainage with the Shaw-Young apparatus is usually preferable.

False passages. Perforations of the urethra, from within, caused by faulty instrumentation, are called false passages. There are usually pathologic conditions present which predispose such injuries. The instrument, usually small, is caught in a fold or crypt or in front of a stricture or anterior to the external sphincter, and perhaps is pushed with undue force. False passages are likely to occur when one or more of the following conditions obtain: the surgeon is inexperienced; the bulbous urethra is relaxed; the point of the instrument is not kept on the roof of the urethra; there are urethral strictures, periurethral abscesses, fistulas, or diverticula; prostatic cavities, due to present or previous disease, exist; or the prostatic masses encroach on the deep urethra.

False passages are called complete when they re-enter the urethra or extend into the bladder; they are called incomplete when the submucous tissues alone are entered.

Symptoms. Hemorrhage from a false passage is usually not severe, though smarting on urination is generally more noticeable than is customary after dilatations. There may be blood clots, retention, swelling and, subsequently, periurethral abscesses. Extravasation of urine sometimes occurs when the false passage is anterior to a stricture and nearly always when the perforation is posterior to it.

Diagnosis. The diagnosis is made by the history and symptoms, by palpation on a bulb or sound introduced into the passage, and by seeing the opening with the urethroscope. When introduced and released, the position a sound assumes indicates whether the instrument is in the urethra or in a false passage. If of long standing, and the conditions permit, the presence of a false passage may be demonstrated, at times, by urethrograms.

Treatment. The treatment of false passages depends largely upon conditions. If patients are able to void, palliative measures only are indicated, such as antiseptics and rest. If there is retention and if hot sitz baths and rest do not afford relief, suprapubic puncture should be resorted to. In the event that extravasation develops, an external urethrotomy should be performed immediately.

Periurethritis and periurethral abscesses. Inflammation may arise in any of the urethral glands, in false passages, or in the submucous tissues following slight extravasation of urine back of strictures and urethral calculi, or from trauma, internal or external. Periurethritis and abscesses may develop in gonococcal or other infections of the urethra. Urethral strictures, with the pathologic changes in the mucous membrane back of them, predispose to abscesses in the perineal part of the urethra.

Abscess of the glands of Littré is the variety of urethral abscesses most frequently encountered. Healing is usually prompt after evacuation of the pus, internally or externally. Fistulous tracts and cavities may remain and harbor infection. Due to the infection and, perhaps, slow extravasation of urine, periurethritis and abscesses may follow dilatation of an inflamed urethra. If the leakage of urine be very slow, a hard mass of fibrous tissue may develop without the symptoms of sepsis.

Treatment. Palliative treatment of hot applications is employed until fluctuation is obtained. The abscesses are then incised. Perineal abscesses may require external urethrotomy in addition to incision. Whenever there is evidence of extravasation of urine, external perineal urethrotomy should be performed, and the tissues into which leakage has occurred should be incised freely. Suprapubic cystotomy should be resorted to promptly in case difficulty is experienced in identifying the deep urethra and entering the bladder. Abscesses of Cowper's glands and of the prostate gland are discussed under their respective headings.

TRAUMA OF THE URETHRA

Injuries of the urethra are classed as internal or external according to their origin.

Internal injuries of the urethra are due to instrumentation by the surgeon or to the passage of foreign bodies into the urethra by the patient. The predisposing factors are urethral strictures, abscesses, prostatic hypertrophy, carcinoma, foreign bodies, calculi, and diverticula. In performing internal urethrotomy, the incision may be made too deep and may result in a downward curvature of the penis, when erect. The urethra may be lacerated also by severe chordee in acute gonorrhea.

Varieties. Urethral trauma may be classified as: (*a*) simple contusion, perhaps with hematoma; (*b*) injury to the extent of a tear of the urethral wall, the bleeding from the urethra, as well as into the corpus spongiosum; (*c*) more extensive damage resulting in bleeding or extravasation; (*d*) complete transverse tear with retraction of the ends of the urethra. In the last two types, extravasation may extend into the penis, scrotum, inguinal and hypogastric regions, bladder and prostatic areas.

Symptoms. Symptoms are bleeding from the urethra, pain on urination, and swelling. Extravasation of urine is not likely unless the meatus is small or the injury is posterior to a stricture. The symptoms of internal rupture or puncture of the urethra depend upon the tissues penetrated and upon the degree of urethral constriction anterior to the injury. The penetration of the urethra by instruments is usually, however, anterior to obstructions, which lessens the likelihood of extravasation of urine. At first the symptoms are slight (rarely severe) urethral hemorrhage, and more than the usual pain on urination. The swelling which develops before the patient voids is, as a rule, due to hemorrhage or edema; that which arises after voiding is usually due to urinary extravasation. When there is no leakage of urine, the lesion may heal without serious trouble, or abscesses may develop. If extravasation occurs, extensive gangrene and sloughs are likely to follow.

External injuries of the urethra. Traumatism of the urethra may result from blunt or cutting objects, crushing injuries of the pelvic bones from wheels of motor cars, trucks and wagons, elevator and railway accidents, projectiles of various sorts, and from falling astride a fence or other object. A prompt diagnosis is often not made because of failure to suspect urethral injury. Of 174,296 war wounds tabulated by the Medical Department of the United States Army, which occurred in the World War, 37 were of the urethra.

Symptoms of rupture of the urethra from external causes. Symptoms of rupture of the urethra vary with extent and location of the injury. The evidences of rupture may be slight at first, but soon swelling from hemorrhage into the tissues may arise. A bloody discharge may appear at the meatus, if the injury is anterior to the external sphincter; if the laceration is posterior to the sphincter the blood will flow into the bladder. When the rupture is extensive or complete, a large amount of urine escapes into the tissues as soon as the patient attempts to void. This extends according to the limitation of the fascias. Infection is almost a certainty.

Crushing fractures of the pelvis may be complicated by injuries of the urethra and bladder, especially if the bones are extensively damaged. The urine, in such instances, extravasates into the region of the bladder, prostate, and ischiorectal fossas.

Urethral rupture subsequently nearly always results in dense strictures, which should be anticipated and treatment by dilatation employed as soon as is feasible. Diverticula may be caused by injuries of the urethra. Sexual disturbances and sterility also may arise from damage to the pudic nerves, prostate, ejaculatory ducts and seminal vesicles.

Diagnosis. The history of perineal, pelvic, or other injuries in which the urethra might be damaged, should lead the surgeon to make careful observations for symptoms of urethral rupture. Bloody discharge, independent of urination, will be present if the injury lacerates the mucous membrane anterior to the external sphincter. If the lesion is posterior to the sphincter, the blood remains in the deep urethra or passes into the bladder and may not appear at the meatus. If the urethral mucosa remains unbroken, the bleeding may be in or along the corpus spongiosum and appear as a hematoma.

The swelling which occurs in the perineum or along the urethra, at first, is due to blood. Later, when the patient attempts to void, the perineal or scrotal swelling increases rapidly as the urine escapes into the tissues. Further efforts to void increase the pain and swelling.

Extravasating urine spreads into the adjacent tissues, confined to a certain extent, according to the location of the injury, by Buck's fascia or Colles' fascia, which may also be lacerated. Later gangrene and sloughs follow. The majority of patients are unable to void; the bladder may be distended, thus differentiating rupture of the urethra from rupture of the bladder. With injuries of the membranous or deep urethra, hemorrhage or extravasation of urine into the pre-vesical or periprostatic areas may occur, and the outline of the prostate may be obliterated.

Catheterization of the urethra is of doubtful value and should not be employed if the symptoms indicate that the urethra is ruptured. If the canal is seriously injured or severed the catheter will not enter the bladder; while, if catheterization is possible, it is unnecessary. When, however, the evidence is indicative of rupture of the bladder, urethral catheterization is permissible in order to obtain a cystogram to confirm or disprove the diagnosis of rupture of the bladder. A prompt diagnosis greatly increases the chances of a successful outcome. If doubt exists, even with slight swelling, an early operation is to be advised.

Treatment of rupture of the urethra. Slight injuries of the urethra may require no special treatment besides urinary antiseptics, rest and the application of an ice bag to the injured part. A stricture should be anticipated and the passage of sounds started about the fourth day after the injury and continued as indicated.

More severe cases require an external urethrotomy at once, preferably while the bladder is distended, to facilitate suprapubic cystotomy, which may become necessary if the bladder cannot be entered through the perineum.

After exposing the urethra through a perineal incision, a longitudinal incision is made in the urethra at the site of the rupture; the roof of the urethra, if severed, is closed by sutures, when possible. Clots and pus should be evacuated and extravasated areas incised and drained. On account of infection and leakage of urine, end-to-end anastomosis of the severed urethra is rarely permissible. An indwelling catheter, with continuous suction, should be employed for drainage.

To maintain patency of the urethra until granulating tissue has become covered with epithelium, McWhorter advocates the use of a seton for several weeks. Suprapubic cystotomy is performed and a long piece of waxed silk is sutured to the end of the retention catheter. Later, when the catheter is removed, the waxed silk is left in the urethra and the end from the external meatus is tied to the end from the suprapubic opening. McWhorter, in the two cases reported, left the two setons in place 65 and 43 days, respectively, and thinks the setons are preferable to catheters for long-continued use.

Banks recommends the following technic in the management of rupture of the urethra: The bladder is opened suprapubically and a fully curved metal prostatic catheter is passed through the internal meatus along the urethra to the point of obstruction at the rupture and a second catheter of a similar type is passed through the external meatus along the urethra until it makes end-to-end contact with the catheter introduced from above. The instrument first introduced is then gently withdrawn and, at the same time, the second catheter is pushed further in, keeping the beaks in contact all the while. In this manner it is possible to introduce the catheter into the bladder without making a false passage. A self-retaining catheter is attached to the end of the catheter protruding suprapubically. The metal catheter is then withdrawn through the external meatus and the rubber catheter simultaneously is pulled into the urethra where it is fixed in place.

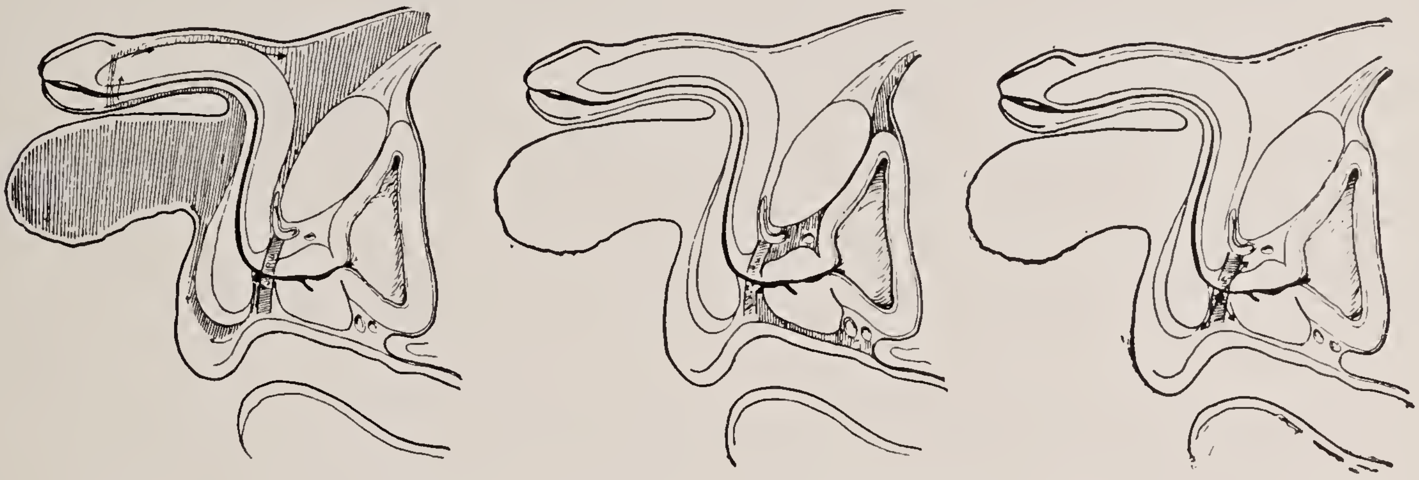

Fig. 44. 1. Spread of extravasation when the primary focal lesion is anterior to the triangular ligament. A course bounded by Colles' and Scarpas' fascias is pursued.

2. When extravasation originates on the pelvic side of the triangular ligament, retroprostatic, perirectal, and ischiorectal infiltrations are most commonly observed although perivesical and pre-vesical involvement may occur.

3. If the extravasation originates within the triangular ligament, extension occurs in either direction, most often externally. (M. F. Campbell.) (Courtesy of Surgery, Gynecology and Obstetrics.)

The bladder is closed and a small drain is left in the space of Retzius. Bladder lavage, with boric acid solution, is instituted on the third day, and about the tenth day the catheter is removed.

In three instances of rupture of the membranous urethra, Banks employed this method successfully and claims for it the following advantages over the perineal incision: The operation can be performed rapidly, which is of importance as most of the patients have other injuries and may have severe shock; there is less scar-tissue formation at the site of the rupture, and suprapubic drainage lessens the danger of extravasation and sepsis.

Ballenger and Elder have found that contact between the instruments is facilitated by the use of a Bransford Lewis tablet depositor instead of the metal catheter for retrograde catheterization. The obturator is left in the tablet depositor until the instruments are in contact. The tip of the catheter introduced from the external meatus, when engaged in the opening of the tablet depositor, makes it easier to maintain the contact without additional damage to the urethra at the site of the rupture.

EXTRAVASATION OF URINE

Etiology. Leakage of urine into the periurethral tissues, into the scrotum, perineum, lower abdomen and upper thighs, arises from damage to the urethral mucous membrane by stricture, calculi, abscesses, instrumentation, and other trauma. A lesion of the urethra may result from the urine being forced through the diseased mucosa back of the stricture or at the site of a urethral stone. Extravasation from trauma may come from internal or external injuries of the urethra. Leakage of urine from rupture of the pendulous and bulbous urethra tends, at first, to remain within the limits of Buck's fascia, while extravasation from injuries of the perineal urethra, guided by Colles' fascia, may spread into the scrotum and lower abdominal wall. Rupture of the membranous urethra soon results in extension into the perineum and ischiorectal fossas; extravasation posterior to the deep layer of the triangular ligament enters the pre-vesical and perirectal spaces and usually results fatally.

Pathology. Extravasating urine is limited to a considerable extent by the fascias; the pathologic changes depend, therefore, upon location of the urethral lesion that permits the escape of urine into the tissues. Guided by the deep layer of the superficial perineal fascia, the leakage is limited usually to the penis, scrotum, lower abdomen, and groins. The skin, at first white and shiny, soon becomes dark red or black and blisters appear; the tissues become infiltrated with gas and crepitate on palpation. Gangrenous sloughs may leave the testicles and cords exposed.

Rupture of the membranous urethra is more likely to permit extravasation into the perineum, the space between the prostate and rectum, pelvic tissues, and the pre-vesical space.

Symptoms. Symptoms of extravasation of urine are pain, difficult urination, swelling, and infection. Hemorrhage is likely to be present in traumatic extravasation. The first symptom is difficult urination; later, attempts to void cause severe pain, burning and tumor formation. Urine, blood and infection are carried into the tissues. If the leakage is slight, abscesses may develop. If the extravasation is extensive, there is not sufficient time for abscess formation. There may be extreme prostration, fever, and hyperleucocytosis. Extensive extravasation is always a grave condition, as the large, diffuse infected tumor quickly gives rise to general sepsis.

Diagnosis. When there is a history of attempts to dilate a stricture, of trauma, external or internal, or of difficult urination following the symptoms just given, extravasation of urine should be suspected and differentiated from epididymitis and abscesses. If the leakage be slight and if only a casual examination be made, the surgeon for a short time may think the painful scrotal mass is an inflamed epididymis. The difference between extravasation of urine from an injury of the urethra and that from a ruptured bladder should be remembered. In the latter the bladder is not distended, there is no hemorrhage from the urethra and no history of instrumentation. If doubt arises, a cystogram should be made at once.

Prognosis. Extravasation of urine, if extensive, is always dangerous and demands an immediate external urethrotomy or suprapubic cystotomy. Previous retention of urine, with the consequent damage of the kidneys, is often a complicating factor in extravasation associated with urethral obstructions. Extensive infection in tissues damaged by urine presents the gravest difficulties; gangrene and sloughs often result. The slower leakage of urine may terminate only in abscesses, which may be incised. Fistulas may follow.

Treatment. The treatment of extravasation of urine depends upon the cause, extent, and rapidity of the leakage. An adequate exit for urine and free drainage of infiltrated tissues should be obtained by multiple incisions. Merely to make the incisions, however, is not sufficient; it is necessary to pass the finger into the incisions, and, by blunt dissection, to open deeper areas and penetrate facias which limit the drainage. Tubes of the Carrel type are placed deep in the tissues.

External perineal urethrotomy is the operation of choice. The pathologic changes, however, may make it impossible to find the deep urethra. In such instances, suprapubic cystotomy and drainage should be done promptly. The critical condition of the patient requires the maximum postoperative attention, especially to combat uremia and infection. Large injections of glucose solution should be administered at once, subcutaneously or intravenously, and repeated every 6 hours until the patient's condition warrants discontinuance of the glucose solution. Passage of urine around indwelling catheters or perineal tubes is lessened if drainage is maintained by the continuous suction method.

The use of lactate Ringer solution should be employed intravenously or subcutaneously as needed, and sulfanilamide cautiously administered.

Dakin solution, or mercurochrome in 2 to 5 per cent. solution, should be injected into the tubes at frequent intervals. Dicloramin-T is also of value in the postoperative treatment of urinary extravasation. The prompt elevation of temperature after removal of perineal tubes may indicate a secondary extravasation, requiring the replacement of the tube. The introduction of drainage tubes is made easier by placing the patient in the extreme lithotomy position.

FISTULA OF THE URETHRA

Etiology. Fistulas of the pendulous urethra are the result of abscesses in the urethral glands, while those of the scrotal and perineal urethra are usually due to the suppuration or extravasation of urine behind urethral constrictions. Fistulas of the deep urethra are nearly always the result of perineal prostatectomy. Injuries of the urethra or calculi may be the cause of periurethral abscesses or extravasation of urine which may terminate in fistulas. A pinpoint meatus, with the consequent back pressure, predisposes to abscesses of the urethra, which may be followed by fistulous tracts.

Pathology. The internal opening of a urethral fistula, as stated, is usually back of a stricture. The outer opening is, as a rule, smaller in the pendulous urethra than in the scrotal or perineal regions. The openings of fistulas may be multiple and the tracts may be tortuous; the lumen may be of fairly uniform caliber or, at times, may be distinctly larger in the mid-portion. The walls of fistulas vary with the age and also with the origin of the fistula. Syphilis, carcinoma, and tuberculosis may be the cause of urethral fistulas.

Symptoms. The symptoms of fistula are the escape, through the opening, of a purulent, mucopurulent, or urinary discharge. The amount of urine passing from fistulas varies from time to time; several days may elapse without discharge and the patient may think for the moment that he is well. Passage of urine through fistulas, except in those of long standing, usually causes a smarting or painful sensation.

Diagnosis. The diagnosis of fistula involves no difficulty. Pressure over the fistula will usually cause the escape of purulent urine from the opening, and the injection of methylene blue solution through the urethra may escape from the fistula, or vice versa. The extent of the fistulas, the location of their internal openings, the character of the tracts, complicating constrictions, and calculi should be determined before an operation is attempted. Probes passed may or may not enter the urethra. Urethroscopic examinations should be done and perhaps roentgenograms made after the fistula has been injected with bismuth subnitrate suspended in oil.

Treatment. Urethral fistulas, recently acquired, tend to close spontaneously when strictures anterior to the internal openings have been adequately enlarged, but rarely while constrictions exist. Intraurethral urinary pressure posterior to strictures and the coincident inflammatory changes definitely retard the healing of fistulas. Closure of fistulas, of recent formation, may be promoted by the injection of germicidal agents, such as mercurochrome in 3 to 5 per cent. solution. Small fistulas, at times, may be cured by fulguration; the exposed electrode is inserted into the tract and the current applied sufficiently to whiten the walls of the fistula. When restoration of the urethral caliber to normal by fulguration, and the injection of germicides into the fistulous tracts fail to cure these sinuses, they should be excised. Tuberculous fistulas should not be excised, except perhaps after primary lesions have been eradicated. Fistulas in syphilitic patients require a full course of anti-specific treatment before excision.

Farman summarizes the salient features of the surgical treatment for the repair of urethral fistulas as follows: "(*a*) removal of the cause; (*b*) restoration of the impaired urethra; (*c*) provision for bladder drainage during the repair of the defect; (*d*) control of infection or active inflammation before beginning any operation of repair."

Regardless of the operation, adequate drainage of the bladder, by retention catheter, perineal tubes, or suprapubic cystotomy, is of great importance. The urethral incision should be closed, partly or completely, as indicated, by interrupted, non-penetrating, fine chromic catgut sutures. Extensive defects in the urethra may be repaired if the edges of the mucous membrane are brought together without undue tension. Unless considerable infection and inflammation are present, the mucosa will quickly regenerate and span the gaps. Subsequent dilatation of the urethra is always necessary and should be continued, with increasing intervals between the treatment, until the caliber is normal or, preferably, above normal.

Urethroplasty. The methods of excision of fistulous tracts, and closure of the urethra and skin, vary greatly with the location and extent of fistulas, and also with existing complications. As already stated, meatal and urethral constrictions require attention before or at the time of the operation. For small, short fistulous tracts in the pendulous urethra, elliptical incisions in the skin, around the opening and deepened to the urethra, permit the removal of the outer part of the fistula and the invagination of the tract near the urethra. The dissection is rendered easier if a sound is introduced previously into the urethra. Small openings into the urethra may not require sutures; larger openings may be closed by purse-string or other sutures, after invaginating the urethral end of the fistula, if its size permits such a procedure. Skin margins and underlying tissues are sutured with number one chromic catgut. As a rule, drainage is not necessary and an indwelling catheter is not required.

For wide defects, incisions should be made with two ideas in mind: (*a*) to obtain suitable skin flaps, and (*b*) to permit the dissection of the urethra sufficiently to close the mucous membrane. The mechanics of the procedure to be employed should be worked out after a careful study of the existing conditions, and before commencing the operation. For extensive fistulas in the perineum, external urethrotomy should be done at the time of excision of the masses of fibrous tissue and fistulous tracts. The identification of the fistulas, when multiple or racemose, is facilitated by preliminary injections of a solution of methylene blue into the sinuses. Closure of the incision, drainage, and subsequent treatment are the same as that given under external perineal urethrotomy. Drainage by continuous suction is desirable.

Recto-urethral fistula. Recto-urethral fistulas are usually the result of perineal prostatectomy, though, in years past, such fistulas sometimes followed perineal stone-cutting operations. When due to operation, trauma, tuberculosis, or carcinoma, recto-urethral fistulas do not heal spontaneously. In case of a small rupture of an acute prostatic abscess into the rectum, conditions are more favorable, and healing may occur sometimes without operation. Distressing as are the symptoms, operative treatment is not to be attempted in carcinomatous or tuberculous fistulas.

More than ordinary care is required for the operative cure of recto-urethral fistulas. Wildbolz, in 1906, and Young and Stone, in 1913, advocated the employment of the Whitehead principle in excising recto-urethral fistulas. The following is a summary of the technic employed by Young: With a de Pezzer catheter suprapubic drainage is provided; the incision is closed and the patient placed in a perineal prostatectomy position. The rectal sphincter is dilated and the perineum and rectum thoroughly washed. A racket-shaped incision is made in the median line of the perineum and around the anus. Scar tissue in the perineum is excised and followed well down to its juncture with the prostatic urethra. The external anal sphincter is carefully preserved. Rectal mucosa and submucosa are stripped up from the sphincter and rectal muscles, exactly as is carried out in the Whitehead operation for hemorrhoids. If a perineal fistula is present, it should be dissected out without injury to the anal sphincter. When this has been done, the sphincter can be drawn forward and the cuff of the rectum separated from it, while dissection proceeds upward in freeing the rectal wall from the prostate. The prostatic tractor, perineal or urethral model, preferably the latter, is used to draw the deeper structures toward the surface and also to afford counter-pressure against which to work. When the rectum has been freed up to the fistula and on each side as far as possible, the fistulous tract is divided transversely and by blunt or sharp dissection the rectal wall is separated for at least 2 cm. higher up, in order to have abundant tissue to furnish a healthy surface of rectum against the urethral fistula. The next step is to close the urethral opening, and this is done after carefully excising the mucous membrane and scar. Two or three layers of tissues are desirable, catgut being employed with the boomerang needle-holder. An effort is made to secure a bulky mass of tissue between the prostatic urethra and rectum. Injuries of the anal sphincter should be repaired and the rectal cuff incised. Closure of the rectum follows the principles of the Whitehead operation. Skin and subcutaneous tissues are approximated with sutures of catgut, silk or metal clips, leaving a small area for a minute rubber-tissue drain into the depths of the perineal wound. No urethral drainage is employed.

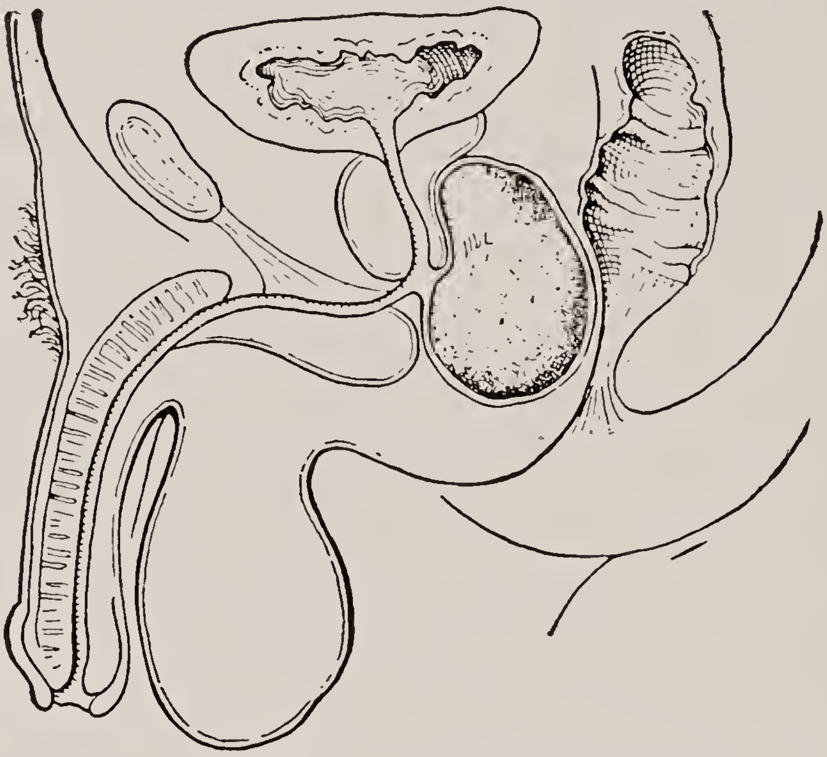

FIG. 45. Diagram of posterior urethral diverticulum and stone (Mouat). (Courtesy of British Medical Journal.)

Subsequent treatment. Great care is taken to maintain suprapubic drainage. Lead and opium pills are given to tie up the bowels for a week. The fecal mass should be softened with liquid paraffin and saline purgatives before finally moving the bowels with castor oil. The perineal drain is usually removed within 3 or 4 days and the suprapubic catheter at the end of 2 weeks.

This operation is always technically difficult because of the indurated scars, infection, and possible necrosis of the rectal wall.

URETHRAL DIVERTICULA

Urethral diverticula have been overlooked in the past largely because their existence was not suspected, and because the genito-urinary surgeon was too often satisfied with cystoscopic examination, without a urethroscopic investigation. Diverticula as a cause of obscure affections are often not discovered because the urethra, especially its deeper part, is not carefully inspected. The foroblique panendoscope has rendered the diagnosis of urethral diverticula easy, and hereafter the number recognized undoubtedly will increase. Bacteriuria and resistant urethritis are the conditions most likely to lead to a search for small diverticula. If there is no infection, no obstruction, and if the diverticulum readily empties, there may be no symptoms present.

Diverticula are said to be *true* or *false*, depending upon the structure of their walls. In the true, the wall is similar to that of the adjacent urethra; while in the false, the wall is composed of fibrous tissue. The former is congenital; the latter acquired. This distinction often cannot be made on account of the secondary changes brought about by inflammation or the presence, at times, of calculi.

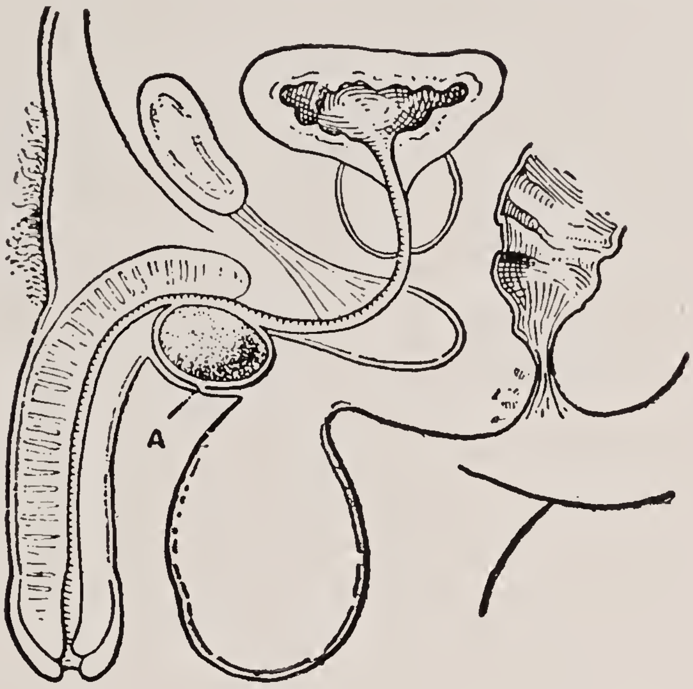

Fig. 46. Diagram of stone (A) in urethral diverticulum (Mouat). (Courtesy of British Medical Journal.)

In an excellent review of the subject, Nicholson states that any classification of urethral diverticula is largely artificial, serving only as a working basis for careful study of the subject, and that this is especially true of those cases having no definite history of stricture; also of certain ones in which considerable secondary inflammatory change has occurred.

Etiology. The cause of congenital diverticula is not known.

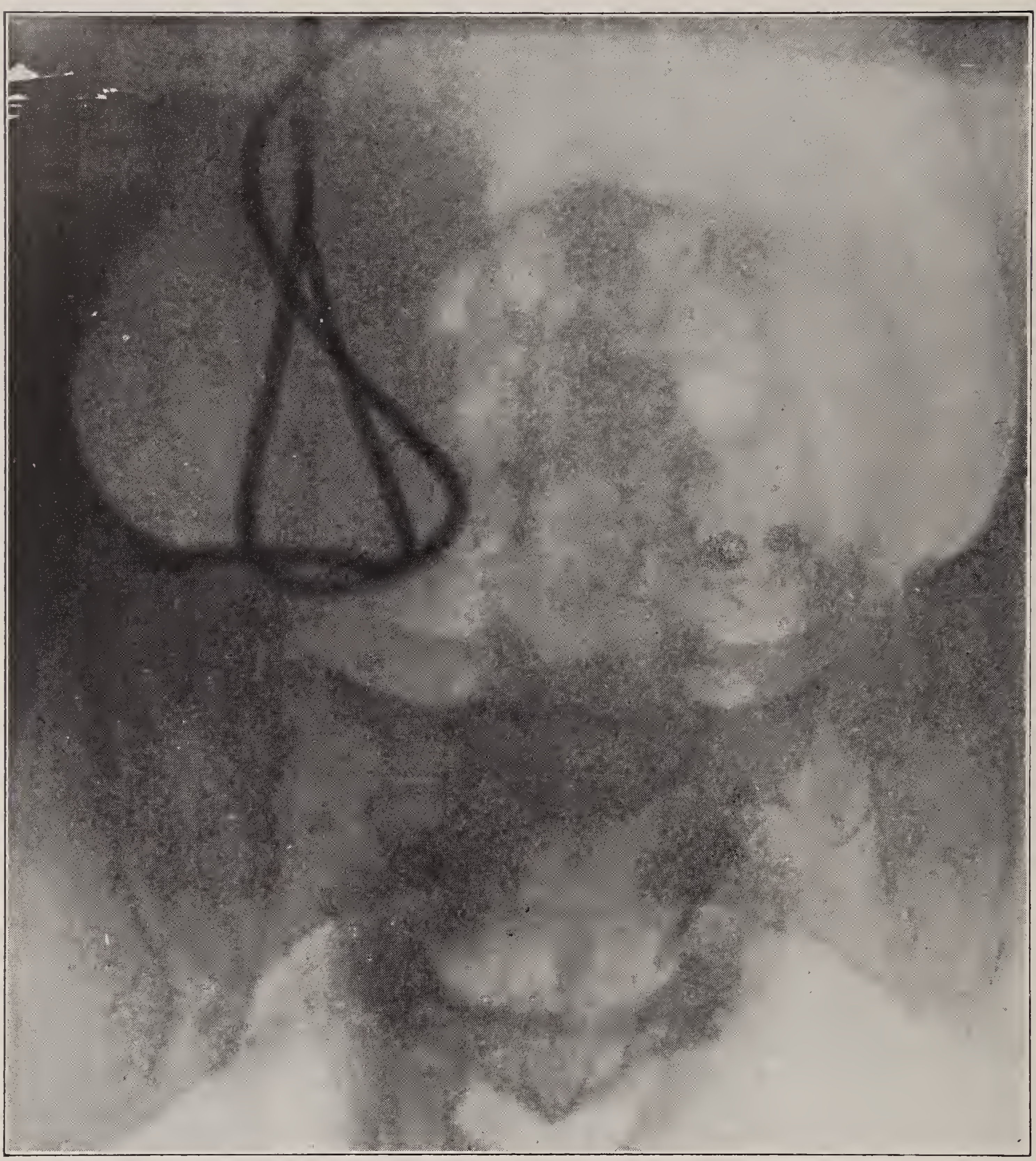

FIG. 47. Roentgenogram showing catheter in a dilated ureter, the lower end of which entered the deep urethra just back of the verumontanum; the upper end was in connection with the lower part of a double kidney. The upper part of the double kidney was drained by a normal ureter which entered the bladder at the usual site. The ureter leading from the deep urethra was markedly dilated, holding 180 cc. and infected with colon bacili, which kept up a low-grade urethritis and bacteriuria. The other ureters were normal in position and gave out normal urine. The urologist cannot but speculate as to the difficulty that would probably have been experienced in the treatment of deep gonorrheal urethritis if the patient had been so unfortunate as to have contracted such an infection. (Ballenger and Elder.)

The comparatively few specimens available for study, the complicated embryologic development of the urethra, and the origin of different portions of the canal from various sources, confused still further by inflammatory changes, make a study of the etiologic factors of congenital diverticula extremely unsatisfactory. Nicholson has pointed out that congenital urethral diverticula, and congenital cysts associated with the urethra, are of entodermal origin; yet, under certain conditions, these diverticula might be derived from the ectoderm. The epithelial lining cannot be relied upon, however, for differentiation.

The etiology of acquired diverticula will usually be brought out by the history of trauma, periurethral or prostatic abscesses, urethral strictures, operations, and rupture of urethral cysts. While calculi lodged in the urethra might be responsible for acquired diverticula, it is more likely that the stones develop in the urine stagnating in the diverticula. English suggests chemical analysis of the stone to give a clue as to its origin; those with nuclei of oxalates or urates arise from the upper urinary tract, while those of phosphates develop within the diverticula.

Urethral strictures, with false passages or abscesses, account for a considerable percentage of urethral diverticula.

Symptoms. In new-born infants, the obstructive feature is likely to be the first symptom noticed. As already stated, congenital urethral diverticula may cause no symptoms. In the majority of instances, however, bacteriuria and, less frequently, a resistant chronic urethritis will be present. Severer symptoms may arise from active inflammation or from urinary obstruction. The symptoms vary largely with the size and location of the diverticula. When the region of the sphincters, verumontanum and deep urethra are involved, there may be frequency, incontinence and dribbling of urine, in addition to infection. Large diverticula in the adult, at times, may cause urinary obstruction.

Diagnosis. Small urethral diverticula are readily recognized by urethroscopy if the irrigating urethroscope is employed, preferably the foroblique panendoscope. With large diverticula, which fill upon voiding and afterward collapse spontaneously, or under external pressure, the diagnosis is obvious. When stones are present, the hard mass may be palpated. The x-ray film confirms the diagnosis. The passage of sounds may or may not be interfered with by the diverticula or calculi. Obstructions are usually anterior to the sacculations. The shape and capacity of diverticula may be shown by diverticulograms. If the orifice is small the cavity may not fill; in such instances, opaque ureteral catheters may be coiled in the pouch instead of injecting the opaque media.

Diverticula are often not recognized because the surgeon fails to suspect such affections as the cause of persistent bacteriuria or resistant chronic urethritis. Bacteriuria rarely is caused by prostatic infections except where there are diverticula in the prostatic urethra. Consequently, when bladder examinations are negative and when the ureteral specimens of urine are free of bacteria, diverticula as a likely cause should be suspected. As a focus of infection, the size of the diverticulum is less important than is the caliber of its orifice. Whereas large diverticula are usually recognized, the medium size and small diverticula of the prostatic urethra are frequently not found, and, as stated above, largely because these sacculations are not looked for. Failure to find diverticula may result occasionally from unsatisfactory urethroscopy; this, however, will be exceedingly rare if urethroscopes of close-vision irrigating variety, or the foroblique panendoscope, be employed.

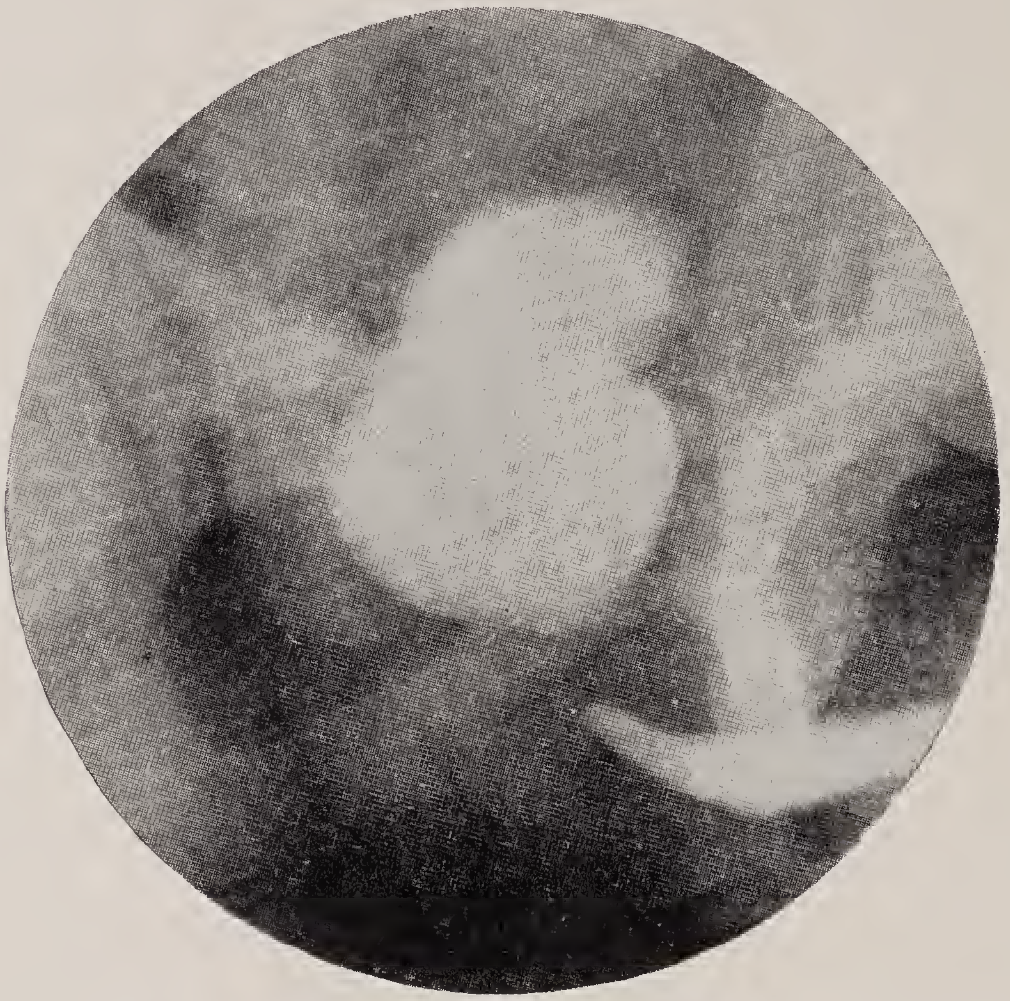

Fig. 48. Diverticulum in the posterior urethra connected with a small contracted bladder. Entire prostate had been destroyed by tuberculosis. After Braasch.

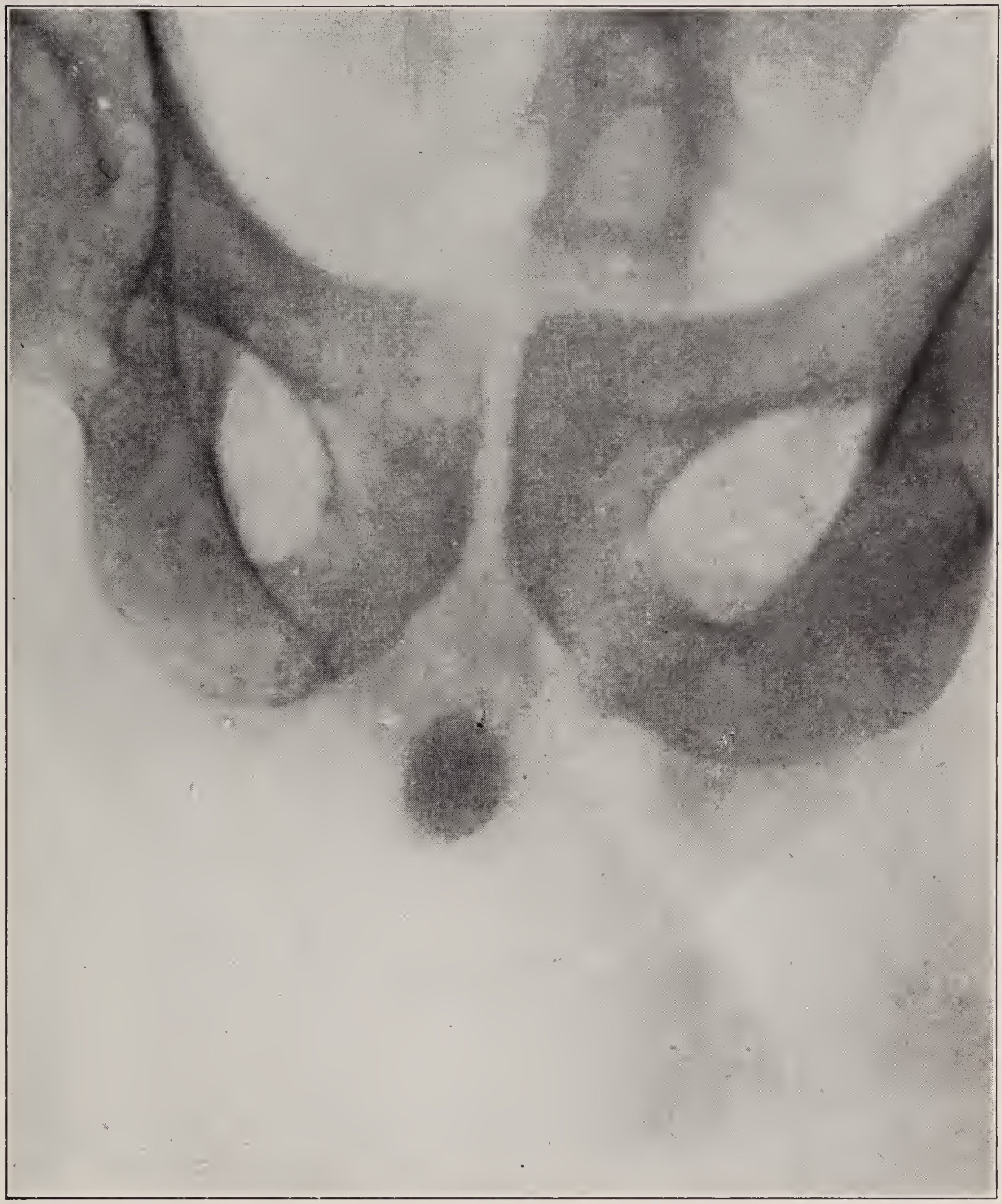

FIG. 49. Stone in the urethra.

Resistant chronic urethritis is not infrequently kept up by small diverticula in the prostatic urethra. Success in finding medium-sized and small diverticula depends upon making urethroscopic examinations whenever a chronic urethritis fails to respond to reasonable courses of treatment and the dilatation of strictures.

Treatment. The treatment of diverticula should be directed along two main lines: (*a*) to eradicate the cavity, and (*b*) to eliminate urethral obstructions. Sufficient, but partial, eradication of small or medium-sized cavities may be accomplished, at times, by enlarging the orifice; in other instances complete eradication may be obtained by opening the cavity into the urethra. Such endo-urethral operations may be done with the high frequency current applied by means of rigid or other electrodes; here, again, the foroblique panendoscope is desirable. Operation by the fulguration method is bloodless. If the frequency of the current be high, only a slight bleeding will result when the fulgurated areas separate. Local or sacral anesthesia is sufficient in the majority of instances. The plan of procedure cannot be determined until careful investigations have determined the etiology, location, size, shape, and characteristics of the walls of the diverticulum and its orifice. Preliminary treatment of urethritis and diverticulitis may be necessary before radical measures can be employed. Diverticula causing obstruction of urine, and those with large sacs in which urine accumulates and stagnates, require operations through perineal incisions. Diverticulograms, cystoscopic studies, and the type of obstructions, if present anterior to the sacs, determine the operative plan. The technic is not unlike that already given for urethral fistula and external perineal urethrotomy.

The presence of large calculi in urethral diverticula requires lithotomy and eradication of the sac if feasible. Suprapubic cystotomy, at times, may be required for removal of large stones in diverticula, or for diverticula which present toward the bladder.

Urethrography. Urethrography is the method of demonstrating the outline of the urethra by roentgenograms after the injection of an opaque medium. As a diagnostic measure urethrography is far less useful than urethroscopic examinations, but in certain instances it is of value. With urethrography the surgeon may demonstrate abnormalities of the urethra such as diverticula, strictures, false passages, fistulas, pouch formations, weakened sphincters, and irregular dilatations of the urethra.

Urethrography should not be employed immediately after urethroscopic examinations, urethral dilatations, or urethral trauma.

The solution should be bland and the injection should not be made with undue force. Silver iodide in a 5 per cent. emulsion is non-irritating and casts a satisfactory shadow.

Technic. The bladder should be emptied of urine and the patient placed in a dorso-lateral position. Silver iodide suspended in oil emulsion is injected until the bladder is nearly full and the exposure made while the opaque medium is flowing. Braasch emphasizes two essential points in the technic: " (1) In order to show the outline of the urethra in profile, the pelvis must be inclined at an angle of 45 degrees with the horizontal, the thigh of the lower extremity must be in extreme flexion, the upper thigh and leg extended, and the roentgen-ray tube angled about 15 degrees toward the feet of the patient; and (2) the opaque solution must be flowing during the entire time of the exposure. If the bladder and urethra are merely filled before the exposure is made, a shadow will not be cast by the posterior portion of the urethra because it will not be distended."

The penis should be held somewhat anterior and toward the lower thigh.

According to Burden, urethrograms indicate that normally the posterior urethra is in a state of tonic contracture and closure; that it maintains this closed condition in the presence of a distending force on either side; that the posterior urethra never becomes a part of the bladder cavity; and that the entire length of the posterior urethra takes part in closing the vesical neck, the internal and external sphincters not acting with separate and independent functions.

The simultaneous injection of fistulous tracts and the urethra with an opaque medium may afford instructive urethrograms, demonstrating the course, size and branching of the fistulas, as well as their relationship to the urethra and prostate.

In case diverticula or other urethral affections are suspected in chronic gonorrhea, urethrograms are less likely to cause disturbing complications than are urethroscopic examinations.

Relaxation of the internal sphincter and shortening of the prostatic urethra in cord lesions may be demonstrated by cysto-urethrograms.

URETHRAL CALCULI

Etiology. Urethral calculi, except those which arise in diverticula or blind passages, nearly always form in the kidney or bladder, and subsequently lodge back of a narrowing, either congenital or acquired. In the female, urethral stones are exceedingly rare.

Pathology. The composition of urethral calculi is similar to

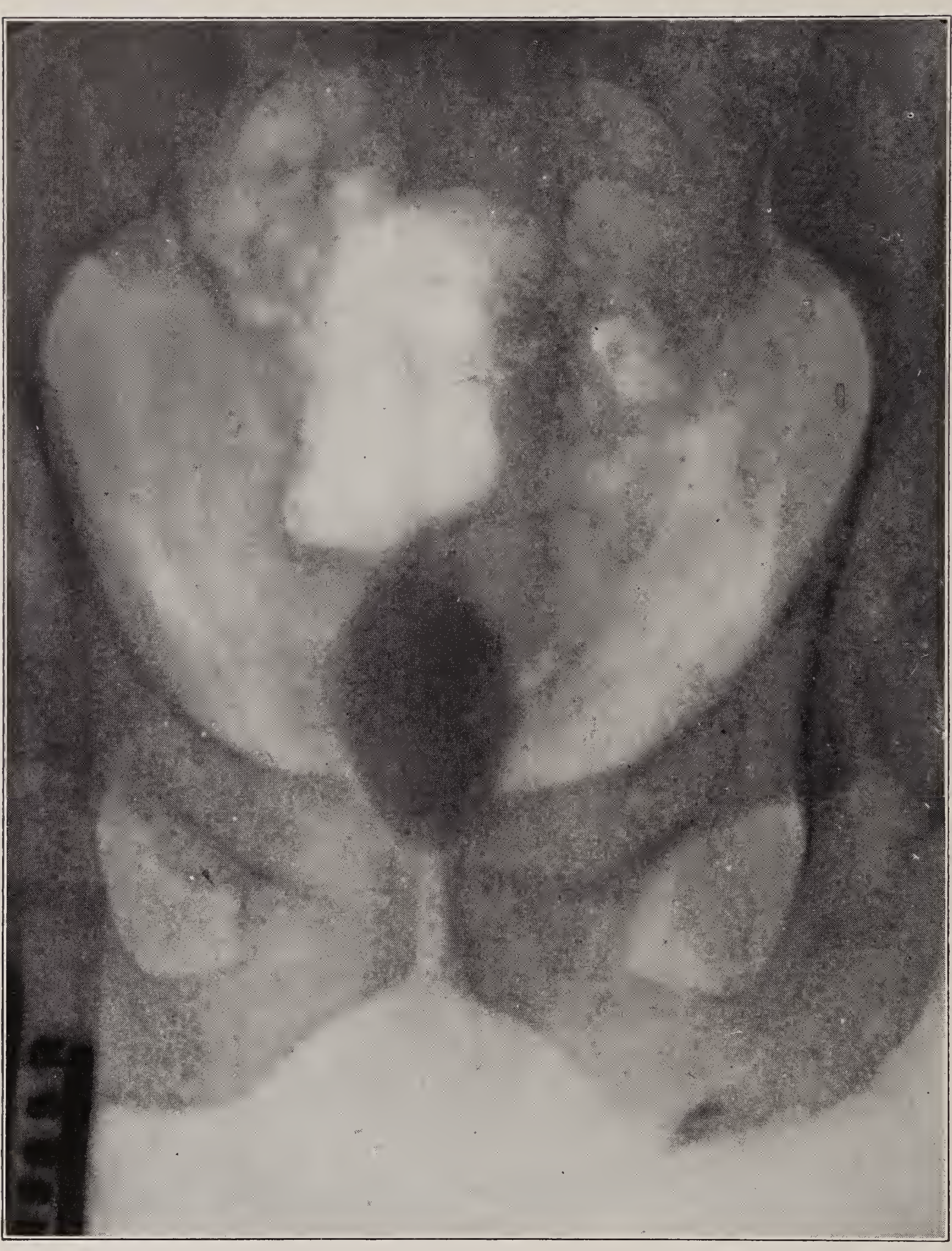

FIG. 50. Vesical calculus which remained in the deep urethra for several years. The internal sphincter was gradually dilated until the stone passed into the bladder.

that of those found in the kidney and bladder. Phosphates predominate in the stones which have remained for some time in the

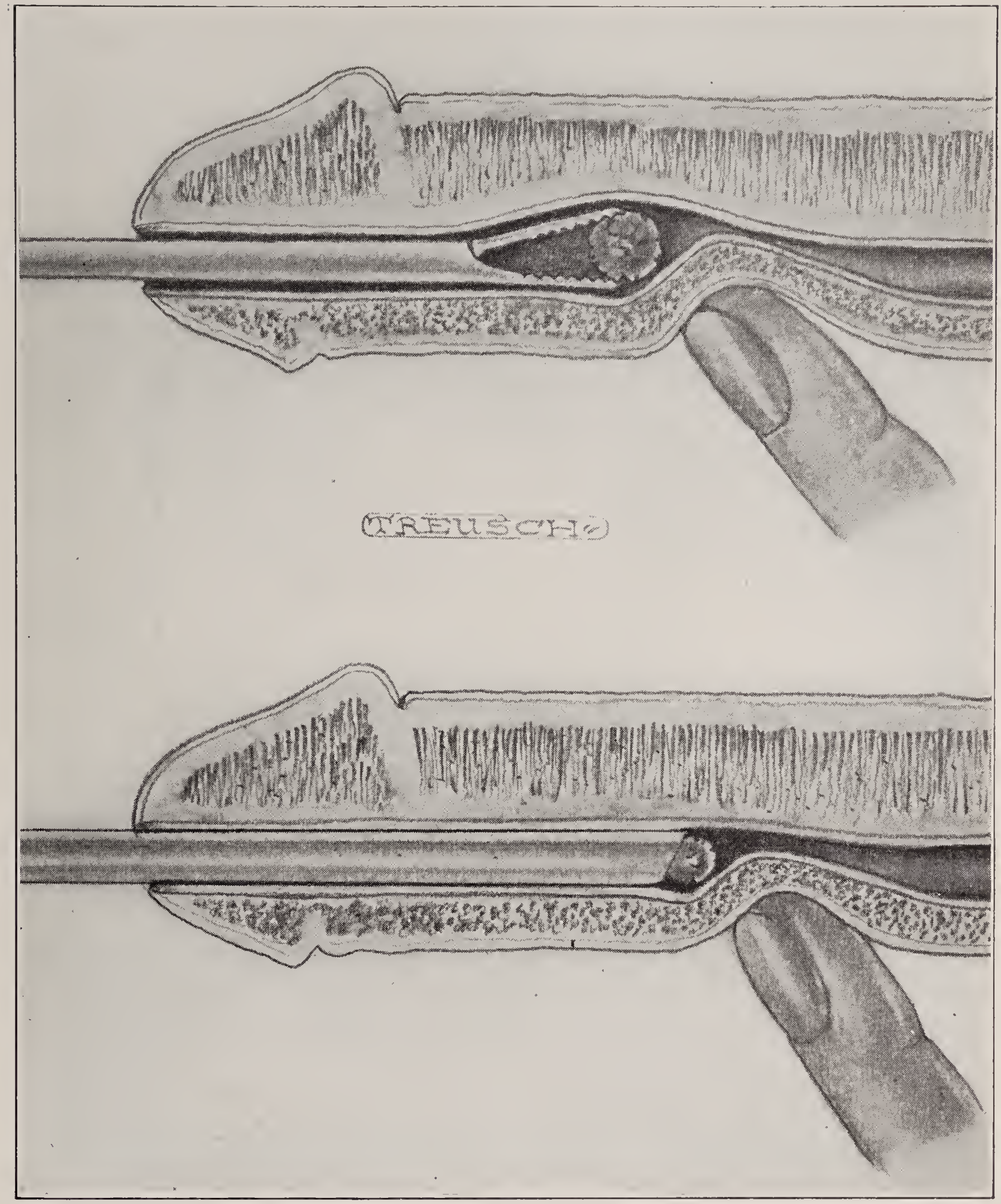

FIG. 51. Upper drawing shows stone being removed by alligator forceps. Lower drawing shows endoscopic tube introduced to calculus in the urethra. The urethra is previously dilated to permit the passage of a tube large enough to allow the stone to be manipulated into its lumen. The surgeon then can remove the stone without trauma other than the preliminary dilatation.

urethra. Urethral calculi vary in size from that of a small pea to that of a pecan; in rare instances they are as large as lemons. The usual seat is just behind the narrowest points in the urethra, namely the meatus, fossa navicularis, penoscrotal juncture, bulbous or membranous urethra. Urethral calculi occasionally lodge in the prostatic urethra; the following roentgenogram shows a large lemon-shaped calculus which formed in the deep urethra, gradually distended the internal sphincter and finally was dislodged into the bladder. The patient had, in addition to the stone, partial paraplegia, continuous dribbling of urine and nearly constant tenesmus. Complete control of the urine was regained after removal of the stone through a suprapubic incision.

Urethral calculi are usually single and, in the majority of instances, do not block the urethra completely. If recently lodged in the urethra, there is only urethritis in the area irritated by the stone; in cases of long standing, the urethra is thickened and there may be constrictions in front of and back of the calculus. Occasionally, calculi lie both in the deep urethra and in the bladder, the central portion being constricted by the internal sphincter. Abscesses, fistulas, and extravasation of urine sometimes result from urethral stones.

Symptoms. A sudden partial stoppage of the urine — rarely complete retention, except in boys — may arise; there may be also pain, burning, dribbling of urine, and frequent urination. Calculi in diverticula, or in the dilated urethra back of a stricture, may cause surprisingly few and mild symptoms; coitus may or may not be painful, and the ejaculation of semen may be sufficient to cause impregnation. The urine is usually cloudy, especially in the first glass.

Young reports a large, round oxalate stone of the bladder which periodically entered the deep urethra where it would remain, causing violent pain, until the spasm was relaxed by morphine and the stone allowed to escape into the bladder.

Diagnosis. Stones near the meatus may be seen by pulling apart the lips of the meatus, or after meatotomy; if deeper, metallic instruments inserted into the urethra elicit a distinctive click or crepitus. If the urethra is palpated along a sound, the calculus may be felt as a hard mass. In case of doubt, roentgenograms and urethroscopic examinations should be made. Large stones in the deep urethra may be palpated through the rectum and, if two or more are present, a crepitus may be noted.

Treatment. The first and most necessary part of treatment is to enlarge the canal anterior to the stone, by meatotomy and dilatation of the urethra and of strictures, if present. Novocaine should be injected into the urethra and retained for 5 minutes, followed by a lubricating oil. A large Kelly endoscope or the foroblique panendoscope should be gently introduced into the urethra to the stone; the obturator is then removed, the tube advanced down the urethra a little further until it touches the calculus. Slight pressure along the urethra back of the stone may cause it to enter the lumen of the instrument; the stone may then be removed with urethral forceps, or if these are not available, and if the calculus is small, the patient should assume a position that will permit the penis to point downward so that the stone may be kept in the tube during its withdrawal. The size of the stone should determine the caliber of the tube to be employed.

Jacobs has suggested the passage of a number of small whalebone filiforms into the urethra beyond the stone; the filiforms are manipulated so as to surround the stone, which will come out with the filiforms when simultaneously withdrawn. Whatever the method employed, dilatation of the urethra, anterior to the calculus, before attempting to remove it, lessens the injury of the mucosa.

The above methods are generally more satisfactory than is the removal of stones with thin-bladed, slightly curved urethral curettes. If the caliber of the urethra permits, the stone may be grasped with alligator forceps and removed. If these measures fail, if the calculus is in a diverticulum, or if strictures are tight, external perineal urethrotomy should be performed. Stones in the mid-penile urethra should be pushed back, when possible, to the perineal urethra for removal by perineal section. Stones in the prostatic urethra may be removed through the external urethrotomy incision; a suprapubic cystotomy rarely is required.

FOREIGN BODIES IN THE URETHRA

Many types of foreign bodies introduced through the meatus into the urethra have been reported in medical literature; the purpose of their introduction is to obtain sexual excitation or is incident to urethral examinations or treatment. Objects which have been found in the urethra are: broken whalebone filiforms, pieces of catheters, dilators, urethrotomes, and forceps; non-absorbable sutures, parasites from the bowels; pencils; penholders; pieces of straw; pins and other substances. Pomeroy reports a urethral stone having as its nucleus a piece of wire.

Complications often arise as a result of curious substances having been inserted into the urethra. Two peculiar cases have been recently observed: in the first, the foreign substance was a pencil-like mass of soap which the patient, in an effort to remove it, had forced into the deep urethra, where it caused a severe inflammation; in the other, an alcoholic patient had inserted a tablet of potassium permanganate into the urethra, where it remained overnight, producing a severe hemorrhage and subsequently a fistula of the urethra near the meatus. Occasionally foreign bodies may pass into the urethra from the bladder, or may pierce the urethral wall; in the latter case, the substance may be a spicule of bone resulting from a fracture of the pelvis.

Symptoms. The symptoms of foreign bodies in the urethra are not unlike those caused by urethral stones. The burning, stinging pain and inflammatory changes vary with the size and character of the foreign substances which are introduced into the urethra. Complete retention of urine is not likely to occur.

Complications. Complications not infrequently observed are: urethritis, edema, periurethral abscesses, fistula, and, rarely, urinary infiltration, cystitis, pyelitis, and pyelonephritis. Foreign bodies, if allowed to remain in the urethra, will become incrusted with urinary salts, usually phosphates.

Diagnosis. The diagnosis is made by palpation of the urethra, on the outside, and per rectum; by urethroscopic examination; by roentgenograms; and by exploring the urethra with bulbous bougies.

Treatment. The method of removing round foreign bodies from the urethra is the same as for calculi. The meatus and urethra should be enlarged, the urethra anesthetized and well lubricated, and an effort made to remove the foreign body, with urethral forceps, through the urethroscope. When such measures are unsuccessful, external urethrotomy should follow.

URETHRAL NEOPLASMS

Primary tumors arising from or in the urethral walls are both benign and malignant. While they hardly can be said to be of frequent occurrence in the male, their presence in both the anterior and posterior urethra is of sufficient frequency to demand more study.

The group of tumors in the female included by the term caruncles, has, owing to their frequency, received considerable attention; this term has been employed generally to cover the class of neoplasms occurring at the outer end of the female urethra. The caruncular growth, in the female, which is of a red color, rich in blood vessels, exquisitely sensitive, bleeds easily and has a glazed, slightly rough, or granular surface, apparently, as yet, has no recognized analogue in the male. Further histologic and urethroscopic studies, however, ultimately may develop the fact that such growths arise in the male but, owing to the extreme differences in local conditions, fail to develop the characteristics typical of at least certain types of caruncles in the female.

Malignant tumors of the urethra are infrequently diagnosed early enough for complete excision.

BENIGN TUMORS OF THE MALE URETHRA

In medical literature, the nomenclature of benign tumors of the urethra is far from exact. The early writers used terms descriptive of the outward appearance of neoplasms. The investigators who later tried to classify the tumors according to their histologic study were unable to harmonize the findings with the older nomenclature, based largely upon the appearance of the tumors.

The type of urethral tumors varies in accordance with the part of the urethra affected. True venereal warts and condyloma are polypoid formations, and may extend from the glans penis into the urethra. In an exhaustive study, Randall, in so far as is possible, groups benign growths of the urethra, from a histologic viewpoint, into types to correspond with the older tumors. The benign polyps of the urethra particularly were investigated by Randall, who uses the word polyp purely as a generic term, because of its freedom from histologic significance, to cover the entire group of benign, pedunculated, or sessile intra-urethral proliferations.

The term papilloma is loosely used in medical literature in describing urethral growths. Von Antal summarized the older macroscopic conception of benign neoplasms of the urethra as follows: " If the tumor has a smooth surface, a broad base and ends sharply, it can be called a caruncle; if it has the same smooth surface but with an outspoken pedicle, it is designated by the name of polypus; if on the surface of the tumor are warty projections, it is termed papilloma; if the tumor has many new-formed vessels, it is called angioma; yet all these conditions represent a fundamental type, a connective tissue tumor."

The present-day conception is that a papilloma should be visibly villous or cauliflower-like in appearance, yet in one of Randall's cases the true pathology was revealed only when a microscopic section showed the tumor to be a villous-forming growth. The term *papilloma* should be limited to neoplasms that arise from the proliferation of the papillæ and their vessels. Randall asserts that there are " three types of benign growth occurring in the male or female urethra, varying as to degree and form of the structure of either the epithelial covering or the stroma, beginning first with the caruncle with its 3 or 4-layered epithelium and loose cellular connective tissue (the older conception); then to the papilloma with its hypertrophied papillæ, formed of a similar stroma with a many-layered proliferating epithelium covering its villous projections; and finally the condyloma, characterized by a dense epithelium and a sparse, cell-poor, and firm connective tissue. However, when we recall to mind the anatomical features of the tissues of the urethra and the fact that these growths may arise from any or all of these tissues, in varying proportions, such sharply drawn subdivisions into caruncle (angioma), papilloma, condyloma, et cetera, becomes a question of degree rather than of kind."

Randall has suggested that the term *condyloma of the urethra* be dropped from the classification of tumors in urethral tumors in the male, and that polyps be classed histologically as follows: (*a*) pure type of benign fibrous polyp; (*b*) villous (or papillomatous) type of benign villous polyp; (*c*) glandular type or benign glandular polyp. The glandular polyps are composed chiefly of glandular tabular structures, with a framework of connective tissue, blood vessels and lymph channels. They arise usually in the prostatic urethra.

Other benign tumors of the urethra are: (*a*) fibroma; (*b*) myoma; (*c*) neuroma; (*d*) cysts. Cysts of the urethra, except when associated with inflammation and urethral tuberculosis, are exceedingly rare. Lowsley, however, observed a cyst of the urethra which was entirely benign and easily removed *en masse* under local anesthesia.

A comparatively rare growth apparently originates from the hypertrophy of the glandular structures and contains definite glandular acini. Burkhardt has found that this new growth, in certain respects, is similar to the so-called mucous polyps of the nose.

In the urethra near the vesical neck there arise bulbous edematous areas of granulation tissue with young connective tissue and spindle-cell formation; this pathologic change is observed more frequently and more extensively in the bladder than in the deep urethra, and is ascribed to lymph stasis and chronic irritation. Associated with such lesions are urinary and sexual disturbances.

Location and number. Benign neoplasms are likely to occur near the meatus, in the posterior part of the bulbous urethra, and in the region of the verumontanum and the urethra posterior to it. Urethral tumors may be single or multiple; Doble has observed instances of papillomas in enormous numbers along the whole urethra, at times obstructing the flow of urine. Papilloma of the bladder may be implanted in the urethra, especially in its posterior part. The urethroscopic appearance of the benign neoplasms varies greatly; the papillomas may appear as irregular, warty excrescences, with slender pedicles or broad bases, which are easily broken off, leaving a freely bleeding surface.

Urethroscopic examinations to determine the cause or persistence of chronic urethritis will enable the surgeon to recognize, not infrequently, pathologic processes as above described. Whether certain types of urethral neoplasms arise as a result of irritation incident to chronic urethritis, or whether the urethral inflammation results from the new growth cannot always be determined definitely; undoubtedly certain tumors are produced by urethritis, while others cause it. Papilloma, being a true neoplasm, arises and continues to grow independently of inflammatory changes. The benign fibrous polyps are associated, usually, with chronic inflammation which involves both epithelium and underlying connective tissue; they do not branch, and often arise at urethral strictures.

Symptoms. Benign neoplasms of the urethra may exist without producing noteworthy symptoms. Usually there is a persistent or recurrent urethral discharge; bleeding from the urethra, except after instrumentation, is far less frequent than might be expected. Tumors near the anterior end of the urethra may project from the meatus; while, if large, neoplasms deeper in the penile urethra occasionally may be palpated along the corpus spongiosum. Tumors located in the deep urethra may cause undue frequency in urination, sexual affections, such as excessive or diminished desire, frequent pollutions, various neurasthenic symptoms, and, in advanced cases, urinary obstruction. Urethral strictures are not infrequent at the base of urethral tumors and probably are causative factors.

Treatment. The possibility of benign urethral neoplasms becoming malignant makes it desirable, when possible, to remove the growth with a snare, urethroscopic scissors, or by fulguration of the pedicle in order to obtain a specimen for examination. Fulguration affords the best method of destroying urethral neoplasms, and even when the growth is removed by other means the base or site of the tumor should be fulgurated, preferably through an irrigating urethroscope. The extent of the fulguration should be guarded, however, to forestall subsequent stricture formation. After the destruction of neoplasms associated with urethral constrictions, gradual dilatation should be employed until an adequate channel is obtained.

MALIGNANT NEOPLASMS OF THE URETHRA

Etiology. Malignant tumors of the urethra are comparatively rare. Kretschmer was able to report from the literature 79 cases, to which he added one. The youngest patient was 38 years of age and the oldest 74. Nothing is known of the etiology of carcinoma of the urethra; stricture is thought to be a predisposing factor. The long-continued irritation at a constricted area in the urethra and the trauma caused by repeated instrumental dilatations produce a protective hyperplastic reaction which occasionally undergoes a transition into malignancy; squamous carcinoma is the result of such a change. Many of the patients give no history of stricture or previous urethral infection.

Pathology. According to the cell type, primary carcinomas of the urethra are classified as follows: (*a*) squamous-cell carcinoma; (*b*) columnar-cell carcinoma (rare); (*c*) papillary carcinoma (rare); (*d*) adenocarcinoma (very rare).

The most frequent type of carcinoma of the urethra is squamous-cell carcinoma (epithelioma). Normally the penile urethra is lined with columnar epithelium except in the fossa navicularis. In chronic inflammatory processes, especially in localized areas and at strictures, the lining cells are changed to the squamous variety.

Imbert further divides malignant neoplasms into two classes: (*a*) those of the pendulous urethra; (*b*) those of the deep urethra. This classification is based, not on the type of the new growth, but upon the course and extension, and the accessibility of the anterior urethra to diagnosis and treatment. Direct extension of malignant tumors of the penile urethra is along the corpus spongiosum and into the corpora cavernosa and skin; lymphatic extension from the pendulous urethra is to the symphyseal and inguinal areas.

Carcinoma of the bulbous and deep urethra extends to the triangular ligaments, perineum, vesical neck, prostate and rectum; the deeper glands associated with these structures are involved in the lymphatic extension. Abscesses, fistulas and urinary extravasation later may arise from the malignant degeneration and obstruction.

Symptoms. Early in the course of malignant tumors there may be no outstanding symptoms to cause an investigation. The character of the symptoms naturally vary with the location of the tumor. Lesions of the anterior urethra may produce urethral discharge or bleeding from the meatus, and may be detected as an induration along the urethra or in the perineum.

Malignant neoplasms of the deep urethra may have no distinctive symptoms. There are usually urinary frequency, obstruction, sexual disturbances, pyuria, and hematuria. The symptoms of carcinoma of the prostatic urethra are practically the same as those of carcinoma of the prostate.

The symptoms of urethral carcinoma have been classified by Kretschmer essentially as follows:

First stage. Early in the course of the disease, the symptoms are practically nil. There may be a small amount of urethral discharge. The obstruction produced by the tumor in the urethra is often the first symptom noted by the patient, and the clinical picture is not infrequently confused with, or coexistent with, stricture; retention of urine, partial or complete, may arise.

Second stage. This stage is characterized by the formation of a local tumor which may be the first symptom observed by the patient. Tumor is a common finding later in the course of the disease.

Third stage. As the disease progresses infection supervenes and there are superimposed the features of periurethral abscess, which has nothing characteristic about it to distinguish it from periurethral abscesses due to other causes. If a patient with this type of abscess is brought into the hospital as an emergency case, the malignant nature of the condition may not be recognized, and this oversight can be readily understood.

Fourth stage. Still later, the clinical picture is further complicated by the presence of fistulas, usually on the under surface of the penis.

Diagnosis. Indurations of the anterior urethra in men of 40 or older, when not accounted for by periurethral abscesses, strictures, syphilis or tuberculosis, should receive careful investigations as to the possibility of such a change being malignant. Rectal palpation of the prostate and vesicles, endoscopic examinations, a search for *Spirochæta pallida* and tubercle bacilli, and Wassermann tests assist in making a correct diagnosis.

The clinical symptoms, difficult urination, perineal induration, fistulas and extravasation of urine, may simulate the symptoms of urethral stricture, which, as already stated, may be a predisposing cause of cancer of the urethra; the recognition of malignancy may not be suspected before external urethrotomy. When masses are encountered at operation for stricture, fistula, et cetera, the existence of malignant neoplasm should be suspected at once.

Carcinoma of Cowper's gland, usually adenocarcinoma, is differentiated from carcinoma of the urethra by the earlier obstruction to the flow of urine in the latter; urethral carcinoma does not grow toward the skin, perineum and rectum, as does cancer of Cowper's gland.

Prognosis. As in cancerous changes elsewhere in the body, the prognosis of malignant tumors of the urethra is unfavorable, except occasionally, when an early diagnosis has been made. Such diagnoses are only possible when careful urethroscopic and other investigations are done promptly in the search for the source and cause of persistent urethral discharge, pyuria, hematuria, urinary and sexual disturbances. The tendency for benign neoplasms to become malignant makes it exceedingly desirable to remove tumors *en masse,* when feasible, so as to permit adequate pathologic studies. Epithelioma of the urethra, like cancer in other localities, is rather late in developing metastases.

Treatment. Only when an early, probably accidental or incidental, diagnosis of urethral carcinoma has been made is it likely that radium will prove of value. The diagnosis, indeed, is seldom made early enough for radical excision. Amputation of the penis and transplantation of the urethra, and complete extirpation of the inguinal glands, may offer occasionally enough hope to justify such radical measures. The urethra should be excised as deeply as is feasible, even though the urine is allowed to pass out through a perineal fistula.

Perineal abscesses and extravasation of urine are managed as described under these headings.

Deep x-ray therapy, while offering not much more than palliation, is preferable to extirpation of urethral carcinomas, except when recognized early and promptly operated upon.

Urinary obstruction may require permanent suprapubic drainage.

Sarcoma of the urethra. Sarcoma of the urethra is exceedingly rare and differs little, except in its rarity, from tumors of this type found elsewhere.

ANOMALIES OF THE URETHRA

Absence of the urethra. When the penis is present, absence of the urethra is an exceedingly rare anomaly. Kaufmann, according to Young, was able to collect only 7 cases. Congenital malformation in which the urethra, after being formed, became totally obliterated and reduced to a solid cord, is rarer still. Urine may drain through a patent urachus or the bladder may rupture into the rectum; otherwise an immediate suprapubic or perineal cystotomy becomes necessary. In two instances reported (adults), with the urethra opening into the bowel, the kidneys did not become infected.

Accessory urethral canals. Young classifies accessory urethral canals as follows:

1. True duplication of the urethra and penis.
2. Accessory canals situated dorsal to the normal urethra.
3. Accessory canals situated ventral to the normal urethra.

A distinction is made between the long accessory canals which run parallel with the urethra, above or below it, and the small paraurethral ducts found at the external meatus or on the surface of the glans.

In a case reported by Cruveilhier, ejaculation of semen took place through the accessory canal and urine was voided through the normal urethra. Accessory urethral canals, as a rule, cause no symptoms unless the patient contracts gonorrhea; when this occurs, a troublesome nidus is afforded for the growth of gonococci.

Double urethra with duplication of the penis is comparatively rare. In this anomaly, the urethras may be separate to the bladder; they may unite before entering the bladder; or each urethra may open into a bladder on the corresponding side. Alan P.

Smith reported an instance of double urethra and double bladder, the man being able to void from either bladder at will. Keyes states that double urethra never exists except with double penis.

Congenital urethral valves. Congenital valves are folds of the urethral mucous membrane which fill during urination and tend to obstruct the flow of urine. These valves are usually found in the deep urethra in the region of the verumontanum. The urethra, as a rule, is dilated back of valves and the bladder may or may not be dilated. There is often hypertrophy of the bladder wall. The long-continued back pressure usually results in hydro-ureter and hydronephrosis.

Frequency. Twelve cases were reported by Young, Frontz and Baldwin from the records of urologic and pediatric services of Johns Hopkins Hospital, and 23 additional cases were collected from literature. Later Hinman and Kutzman reported 6 cases and collected 50 from literature.

Etiology. Among the several theories advanced to explain the origin of congenital valve formation in the deep urethra, that of Tomatschew is more in harmony with the embryologic facts than are the others. He believes these valves to be a simple modification and enlargement of the folds and ridges which are normally present in the deep urethra.

Symptoms. The symptoms are difficult, painful and frequent urination, dribbling of urine and retention. The continued back pressure lowers the renal function and favors infection; later there may be chills, fever, nausea, vomiting, et cetera.

Diagnosis. The diagnosis is made by cystograms and urethrograms or by urethroscopic examinations. The history of a distended bladder in children should at once suggest the likelihood of valves being the cause. The valves often do not interfere with the passage of catheters or instruments; this fact may mislead the surgeon into thinking that urethral obstruction does not exist. Sudden withdrawal of large amounts of urine, when the obstruction is due to valves, is attended with the same dangers that occur when the obstruction is caused by prostatic hypertrophy and stricture; the immediate emptying of the bladder, therefore, is contraindicated when urethroscopy and cystoscopy are done. Fluid injected into the bladder for cystograms often flows up the dilated ureters and thereby affords excellent pictures.

Treatment. The treatment of obstructive urethral valves depends upon circumstances, the degree of obstruction (urinary and instrumental), age, and condition of the patient. If urethroscopy is feasible, the valves may be incised with high frequency fulgurations. Both preliminary and subsequent dilatations of the urethra may be required, before adequate endo-urethral measures may be employed. Young has devised a " baby " punch to remove valves.

The procedures followed by Young, at the Brady Urological Institute, for congenital valves were:

Suprapubic cystotomy with destruction of valves	4
Punch operation	4
Suprapubic cystotomy and punch operation	2
Suprapubic cystotomy and external urethrotomy	1
Rupture of valves per urethroscope	1
Exploratory laparotomy	1
No operation	4

Of these 17 cases, 12 were operated on, 9 were reported as cured, 3 markedly improved, 4 died shortly after admission, and 1 after an exploratory laparotomy. One died of renal insufficiency after being in the hospital one month.

THE VERUMONTANUM

Synonyms: **Colliculus seminalis, cornucula seminalis, caput gallinaceum, crista urethralis, schnepsenkopf.** In the older books considerable space is devoted to the anatomy of the verumontanum, but little or none is given to its histology and pathology. Indeed, even the descriptions of the anatomy of the verumontanum are far from accurate. Rathke was the first to direct attention to the analogy of the verumontanum to the uterus; his studies were carried out on the genital organs of pig and sheep embryos. The similarity of the specimens was so marked that the male organ scarcely could be differentiated from the female. Grunfield was the first to make urethroscopic studies of the verumontanum.

General recognition of pathologic changes of the verumontanum were not generally recognized until about the second decade of the twentieth century. The anatomic position of the verumontanum made it inaccessible for observation with the ordinary cystoscope, and it was not until the advent of the close vision cysto-urethroscope that accurate or satisfactory studies were made. Even today diseased conditions of the verumontanum and the utricle are recognized less frequently by the average urologist than are the common bladder affections; yet, the inflammatory and other pathologic processes of the verumontanum and sinus pocularis play not an unimportant part in urinary and sexual disturbances of the male.

Physiology. The exact function of the verumontanum is not known. For a considerable time it was thought to become sufficiently engorged during coitus to prevent, at ejaculation, the regurgitation of the semen into the bladder. Extensive studies were made by Walker to determine if this was the function of the verumontanum; he elaborated eleven objections to this view and concluded that its function is to assist in mixing the semen with the prostatic secretion. While its position, as well as the converging of the ducts of the prostate toward the verumontanum so as to eject their secretion in the direction of the openings of the ejaculatory ducts, indicate the likelihood of such a purpose, it is not impossible that the verumontanum may be merely a vestigial organ, as is the clitoris. The verumontanum is not a cavernous structure and its function, therefore, cannot be of an erectile character.

The *sinus pocularis* secretes a thin alkaline secretion which, as an adjuvant to the prostatic secretion, may assist in enlivening the spermatozoa.

Rytina observed, however, that excision of the verumontanum and the sinus pocularis in no way interferes with the fecundity of semen. The ejaculatory ducts rarely open into the sinus pocularis.

Pathologic changes of the verumontanum and utricle. The pathologic changes of the verumontanum and utricle may be classified as: (*a*) congenital anomalies; (*b*) inflammation and abscesses; (*c*) infiltrations, soft and hard; (*d*) hyperemia; (*e*) adhesions; (*f*) neoplasms and cysts; (*g*) traumatism and chemical injuries; (*h*) strictures of the seminal ducts and closure of the opening of the utricle.

Absence of the verumontanum is rarely observed. The various affections of the verumontanum have been described according to appearance as: hypertrophied, distorted, inflamed, abscess, covered with granular areas, hood-shaped, cap-shaped, covered with large, small, or multiple cysts, papillomatous, phallus or sausage-shaped, pointed, dome-shaped, sunken, fungus-shaped, attached by adhesive bands to the adjacent urethra, large or small openings of the utricle, large or small ejaculatory ducts, tumors, formations, et cetera. The injection by over-enthusiastic urologists of a concentrated solution of silver nitrate into the utricle, has resulted in destructive changes of bizarre and unusual shapes. After repeated applications of concentrated silver nitrate or extensive fulguration, the verumontanum may not be recognizable.

Foci of infection in the utricle not infrequently hinder the cure of chronic urethritis, especially gonorrhea. Associated with the majority of the affections of the verumontanum are, nearly always, urethral strictures and prostatitis.

Symptoms. The symptoms of affections of the verumontanum are chiefly sexual and urinary. Excessive or persistent masturbation in boys at the age of puberty should suggest the possibility or likelihood of an abnormal condition of the verumontanum being a causative factor. Prolonged ungratified sexual desire may result in hyperemia of the verumontanum, which often is rendered evident by discomfort or itching in the deep urethra, perineum or genital organs, and by frequent urination. Persistent or recurrent chronic gonorrhea, or other infections of the urethra, may be caused by utricular foci. Involvement of the verumontanum and utricle in posterior urethritis probably always occurs, and many of the more or less remote urinary and sexual disturbances, which sometimes follow gonorrhea, are due to utriculitis.

The outstanding affections which not infrequently are caused by diseased conditions of the verumontanum are the so-called sexual " neurosis " or sexual " neurasthenia," premature emissions and impotency. In some instances, inflammation, hyperemia, or other affections of the verumontanum, at first result in excessive sexual desire as well as an abnormal potency, which later is followed by impotency, more or less complete. Mental disturbances and " nervousness " are often found as a result of inflammation, hyperemia, or other affections of the verumontanum. It seems unnecessary to record the multitude of complaints and sensations which these patients delight in detailing. The essential factor is not to rely upon the symptoms for the diagnosis but upon urethroscopic examination and the beneficial result of appropriate treatment of the diseased verumontanum. Blood in the semen and hematuria occasionally result from abnormalities of the verumontanum and the ejaculatory ducts.

Diagnosis. The above-mentioned symptoms of affections of the verumontanum also suggest the likelihood of posterior urethritis, stricture, chronic prostatitis and seminal vesiculitis. These conditions should receive appropriate treatment before any effort is made to diagnose or treat the affections of the verumontanum directly. After reasonable measures have been employed to alleviate the associated affections, a urethroscopic examination should be made with an irrigating urethroscope; if the appearance of the normal verumontanum is known, the pathologic lesions then become apparent.

Treatment. The treatment of lesions of the verumontanum naturally varies with the type of pathologic process present, as well as with the symptoms. There are two valuable measures to employ; namely, fulguration and applications of concentrated solutions of silver nitrate. Both of these agents have specific indications. For abnormal growths, adhesive bands, and frequency in urination, fulguration should be used; for the majority of sexual disturbances, especially impotency, applications of silver nitrate are indicated. The irritation and other changes produced by silver nitrate are probably the most effective agent in restoring the sexual function, whether the complaint be premature emissions or inadequate erections. Fulguration may decrease the precipitancy of organisms but, lacking the irritation and other effects of silver nitrate, may be followed by a decrease in sexual capacity, and the patient may think the cure of a minor symptom has resulted in a major disturbance.

Broadly speaking, it may be said that affections of the verumontanum which produce urinary symptoms, and those which are associated with foci of infection in the utricle, should be treated by fulguration; while the conditions in which the sexual symptoms predominate should receive applications of silver nitrate. This rule, however, is subject to considerable variations. In spite of the fact that able urologists assert that fulguration should supplant the use of silver nitrate, considerable experience over a period of many years still seems to justify the claim that silver nitrate has a definite field of usefulness which fulguration does not supply.

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COWPER'S GLANDS

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HISTORIC COMMENT

The two compound tubular structures situated between the layers of the triangular ligament, anteriorly to the prostate, and known as the bulbourethral glands were first described by Mere[1], of Paris, in 1684. Due however to the fact that William Cowper[2], in 1699, published the first detailed account of these entities, they have been given the name of Cowper's glands. A most minute investigation of these glands was carried out by Gubler[3] in 1849. Lebreton's[4] thesis of 1903 and Eggerth's[5] work in 1915 added much to our knowledge concerning these obscure structures. Finally Johnson's[6] illuminating embryological study, in 1920, leaves little more to be contributed from this standpoint.

Without fear of contradiction it can safely be stated that of all the structures in or adjacent to the urogenital tract of the male, Cowper's glands have received the least consideration. This is observed in reviewing urological texts as well as in pursuing general medical literature. The attention of the profession needs to be drawn more emphatically to the part Cowper's glands play in chronic urethral infections and to the serious sequelæ which may ensue where the condition is overlooked.

Embryology and anatomy. According to Johnson[6] the bulbous urethra is essentially similar to the membranous urethra, containing a similar epithelium and presenting almost identical folds of its mucous membrane. Extending from the rectal surface of the bulbous urethra are two bulbourethral glands. The beginnings of these glands he found present in the youngest embyro examined. Histologically Cowper's glands are of the compound tubulo-alveolar variety, both ducts and alveoli containing numerous mucous cells. Those of the ducts, including the main ducts, are arranged in scattered groups, which may take the form of an alveolus or may remain flush with the surface of the duct. Because of their secretory character Lichtenberg[1] insists that these should not be considered purely as excretory ducts, but as integral portions of the glands themselves.

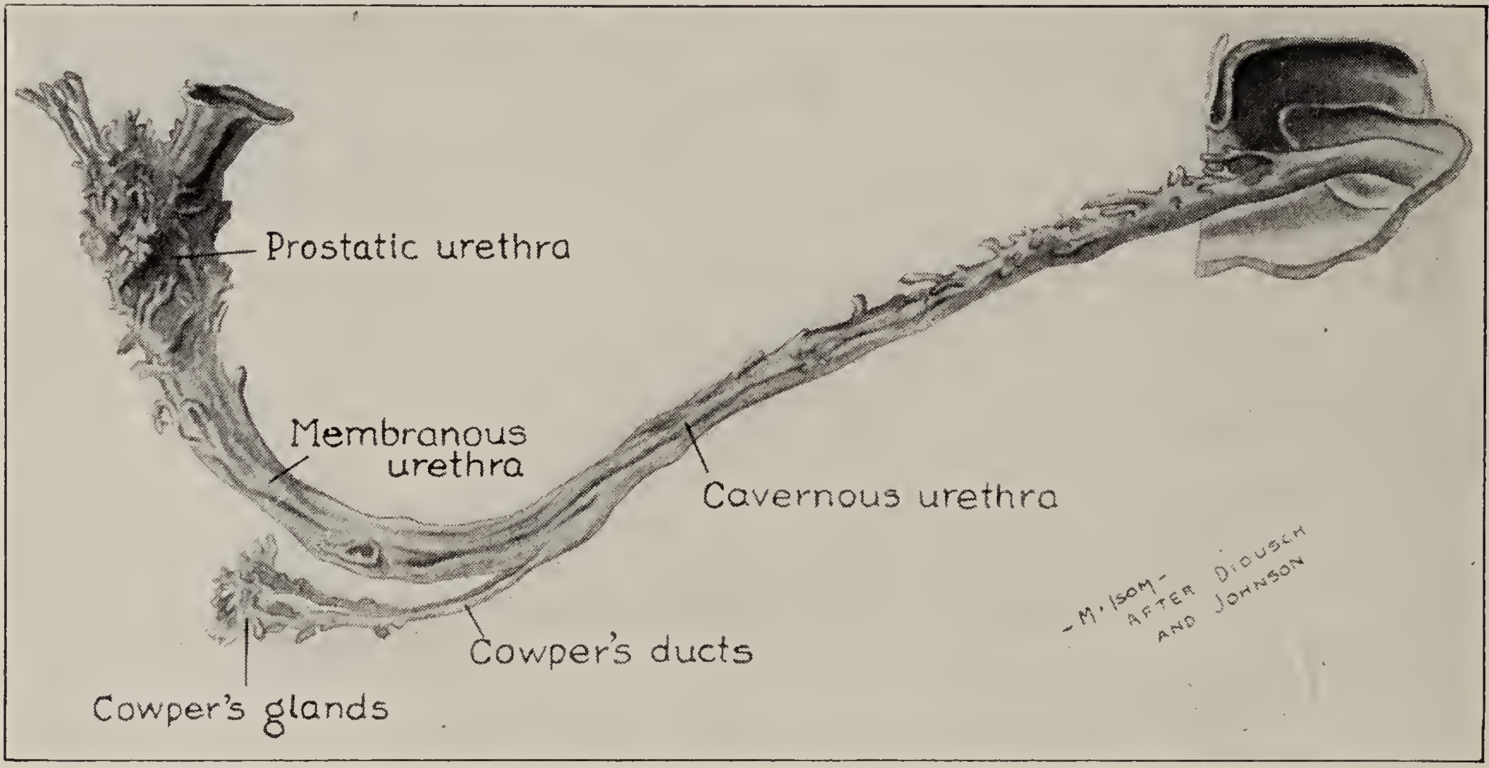

FIG. 1. Johnson's wax-reconstruction of the male urethra showing the relationship of Cowper's Glands to contiguous structures.

Cowper's glands, according to Johnson[6], arise as two solid outgrowths of epithelium from the rectal wall of the bulbous urethra. In the embryo of 55 mm. crown-rump length they are already of considerable length, and course bladderwards, one on either side of the midline, parallel to the urethral tube. In an embryo of 75 mm. the ducts show definite lumena and the beginning of branches. In specimens of 88, 90, and 100 mm. numerous branches are formed and the lumena have grown out into some of the larger branches. At 130 mm. the terminal branchings have become extensive and the ducts have pushed upwards through the bulb and lie above it. In addition there are developing at this stage several small branches from the main ducts. These branches always remain within the bulb and have been termed the intrabulbous portion of Cowper's glands. In succeeding stages the branching becomes more and more profuse, alveoli are formed at the ends of the branches, and the epithelial cells of the alveoli and certain of those of the main ducts become converted into mucous secreting cells. The further development of the glands consists in merely growth changes in these portions.

As **anomalies** of the ducts of Cowper's glands are not of infrequent occurence in the adult, so in fetal stages one finds variations. In specimens of 190 and 320 mm. the duct of the right side alone reaches the urethra; in the latter case the left duct had pushed across the midline and joined the right. Such maldevelopments may account for the clinical observations of Fuller[8] who remarked that he had never observed both glands affected in the same individual.

Cysts of the ducts of Cowper's glands were found in embryos of 310 and 320 mm. In addition to Cowper's glands there sometimes develop, in the bulbous urethra, accessory Cowper's glands. The mouths of the ducts of these glands open into the urethra proximal to those of the main ducts. The accessory ducts are shorter, lie nearer to the urethra than the main ducts but parallel them. The terminal branches are found within the bulb.

ANATOMY

The name bulbourethral glands has been given these structures because they are found situated in the angle formed by the bulb of the urethra. In going towards the surface of the perineum, after an incision is made in the superficial layers, the glands of Cowper are found opposite the triangular space between the bulb and the cavernous body. It is limited by the inferior or superficial lamina and the inferior lamina of the perineal aponeurosis. Placed between the small superior lamina and the inferior lamina of the middle aponeurosis one usually finds two of these glands. Sometimes one of them is missing, usually on the right. They are most often rounded or oval yet sometimes one finds elongated or flattened forms. Their size varies from 2.5 mm. to 7 mm. From the anterior and superior angle of the gland springs an excretory duct which is directed obliquely forward towards the top and which, after passing internally above the bulb, buries itself in the urethra, crosses its wall and ends in a small opening. These orifices of the canals are placed side by side; that on the left may be placed a little anterior to the one on the right.

One distinguishes three parts to the canal, namely, the retro-bulbar part, the intra-spongious and the submucous. The total length of the canal is 2 cm. to 3 cm. It must be remembered that besides the two principal glands one may encounter accessory glands, embedded in the spongy substance of the bulb, astride the canal, which finally empty their contents into the main duct. One can easily understand that with such a complexity in structure excision of the entire bulbourethral system, when feasible, offers the only positive cure to the individual affected.

Cowper's glands receive their **blood supply** from the bulbar artery; the vessel is, in most instances, quite superficial in relation to the gland. It is well to remember this where surgical intervention is contemplated. The venous supply from the bulb is much more deeply situated than the arteries and is therefore of less importance surgically.

Nerve supply. The innervation of the glands is derived from thin nerve fibres which accompany the blood vessels and arise from the hypogastric plexus.

PHYSIOLOGY

Functionally, the bulbourethral glands should be enumerated among the genital glands. During the sexual act, from the initial erection until the orgasm, they are active in contributing their peculiar secretion to the stream composed of the secretions of the other genital glands, which combine to form the seminal fluid. This secretion serves as a urethral lubricant. Pasteau[9] observed that these structures, provided with collectors, situated in the muscular diaphragm, infiltrated with muscular fibers and innervated by rami of the genital nerves, play an important part in the sexual act. At the moment of ejaculation they undergo rhythmic contractions and expel their secretions in a manner analogous to that of the more important genital organs.

PATHOLOGY

Leszcynski[11] studied 44 biopsy specimens of Cowper's glands, sectioned in series, with the following results: in 16 or 36.36 per cent. of cases there was demonstrated definitely either a post-inflammatory or an actually active inflammatory condition; in 2 cases or 4.55 per cent., senile degeneration was noted; 1 case, 2.27 per cent., of cystic degeneration; and, 25 or 56.81 per cent. showed a normal condition. Lymphocytic infiltrations were observed in 9 or 20.45 per cent. of the glands studied. One subject out of every five had, at the time of his death, cowperitis from which he had not recovered.

Although infiltrations are occasionally observed around the vessels, in the majority of instances they are to be found around the excretory canals. It is to be observed that while older alterations lay around the hilum, those of more recent date are noted near the periphery of the bunches; in a few cases they were found principally central. Occasionally the process attacks certain lobules while those adjacent remain intact. Inflammation reaches first the hilum, the place where the principal canal penetrates into the gland. Through the canals, the process extends towards the depth of the glandular parenchyma, causing pericanicular inflammation, indicated by lymphocytic infiltration.

At a later period there develops new granulomatous tissue with some remaining infiltration. The connective interstitial tissue is abundantly increased and cicatrizes with time. The cicatrization and retraction lead to either atrophy of the glandular tissue or to cyst formation.

DISEASES OF COWPER'S GLANDS

Acute cowperitis. The diplococcus of Neisser is practically the sole exciting factor in the production of inflammations in Cowper's glands. At one time, invasion of this gland by infection was considered a relatively rare affection. Today reports from the most reliable sources force us to conclude otherwise. Quite recently, in an analysis of 200 clinic cases suffering from gonorrhea, Schischow and Smirnow[11] found that 25 or 12.2 per cent. demonstrated invasion of Cowper's glands. Most recent observers, who have taken the pains to investigate their patients assiduously, have arrived at similar conclusions as regards its incidence.

The *diagnosis* is usually made by eliciting a history of exposure, by a train of symptoms which are fairly characteristic, and by bidigital palpation of the indurated structure in question. Pain in the perineum of varying degree, a distinctive sense of weight in the affected region with a tenseness which finally becomes most excruciating. This painful sector may be limited either to one or the other side of the median raphe and usually radiates towards the rectum and thighs. The ache may remain dull throughout but at times it is lancinating to the extreme. The structures which harbour these glands are most unyielding, hence the intense suffering frequently experienced in neglectful patients. As the inflammation progresses the swelling, usually left-sided, in the perineum, becomes unbearable and urination and defecation may bring on most agonizing paroxysms of pain. High fever, rigors, an increased leucocyte count, and a palpable mass complete the diagnostic evidence.

Obviously, it is most desirable to recognize the process before abscess formation occurs. This, however, is not always easy. McDonagh[12] very naïvely remarks that many times enlarged Cowper's glands are missed because the observer does not know exactly how to locate them. Unquestionably, there is some truth in this surmise. By careful palpation in the region of these structures, at frequent intervals, many cases can be recognized early and the proper therapy instituted. It is only in the early stages that abscess formation can, at times, be aborted. Luys[13] recommends *massage* of the gland at this stage. After the patient has voided, he fills the bladder with boric acid solution, the inflamed gland is now massaged as vigorously as the patient's condition will permit (care being taken not to touch the prostate). With the forefinger of one hand inserted into the rectum, the thumb of the same hand is pressed against the triangular ligament. The forefinger feels for the region of the symphysis and then gradually works outwards on either side, remembering always to keep pressing anteriorly and, in the lateral course, the gland will be felt. Massage can now be carried out. Following this procedure the patient empties the bladder contents into several glasses. The first of these contains the products of the infected Cowper's gland which can, after being centrifugated, be carefully examined microscopically.

Where massage fails, urethral dilatations with a Kolmann dilator frequently will reëstablish drainage from the affected pus focus. Urethroscopic examinations have been found of inestimable value in such cases, in our clinic. Upon several occasions, where the infection in the gland had burrowed towards the urethral lumen, application of the high frequency spark through the Buerger cysto-urethroscope instantly evacuated the gland with prompt subsidence of symptoms. Where all of such methods of urethral approach fail, perineal incision becomes imperative.

Diathermy has received little attention from urologists in general. In probably no instance can it be used to better advantage than in acute and subacute cowperitis. Many years of experimentation with electrothermic methods convinces us of its value in clinical urology.

Diathermy is today recognized as the most efficient means of applying intensive heat, deep within the tissues. Its use in the treatment of arthritis, epididymitis, endocervicitis and a host of similar infectious processes is well established. However, its application to Cowper's gland infections has not been mentioned in the literature so far as we have been able to determine.

The technique is simple. With the ineffectual electrode of the d'Arsonval current hook-up placed on the suprapubic region and the Y-shaped, active electrode applied to the gland region by inserting one prong of the electrode into the rectum while the other arm rests against the perineum, the heat from a good diathermy machine is permitted to flow between the two electrodes. See Fig. 2. As the plate on the abdomen is much larger than the rectal electrode, the heat is centered fairly accurately to the area of the affected Cowper's glands. Treatments are usually of thirty minutes duration, given daily, with current of from 800 m.a., to 1500 m.a., beginning with a very low degree of heat and gradually increasing the temperature in the electrode to tolerance. The milliamperage dosage will naturally depend upon the degree of inflammation present. In the beginning, the patient will not tolerate as high a degree of heat as can be borne after two or three applications. Success in these procedures is, in our opinion, only to be expected where the urologist or the physiotherapist personally administers the treatment. Obviously, unless diathermy is administered properly, it will be of no value. So-called ' technicians ' frequently make cases worse instead of better.

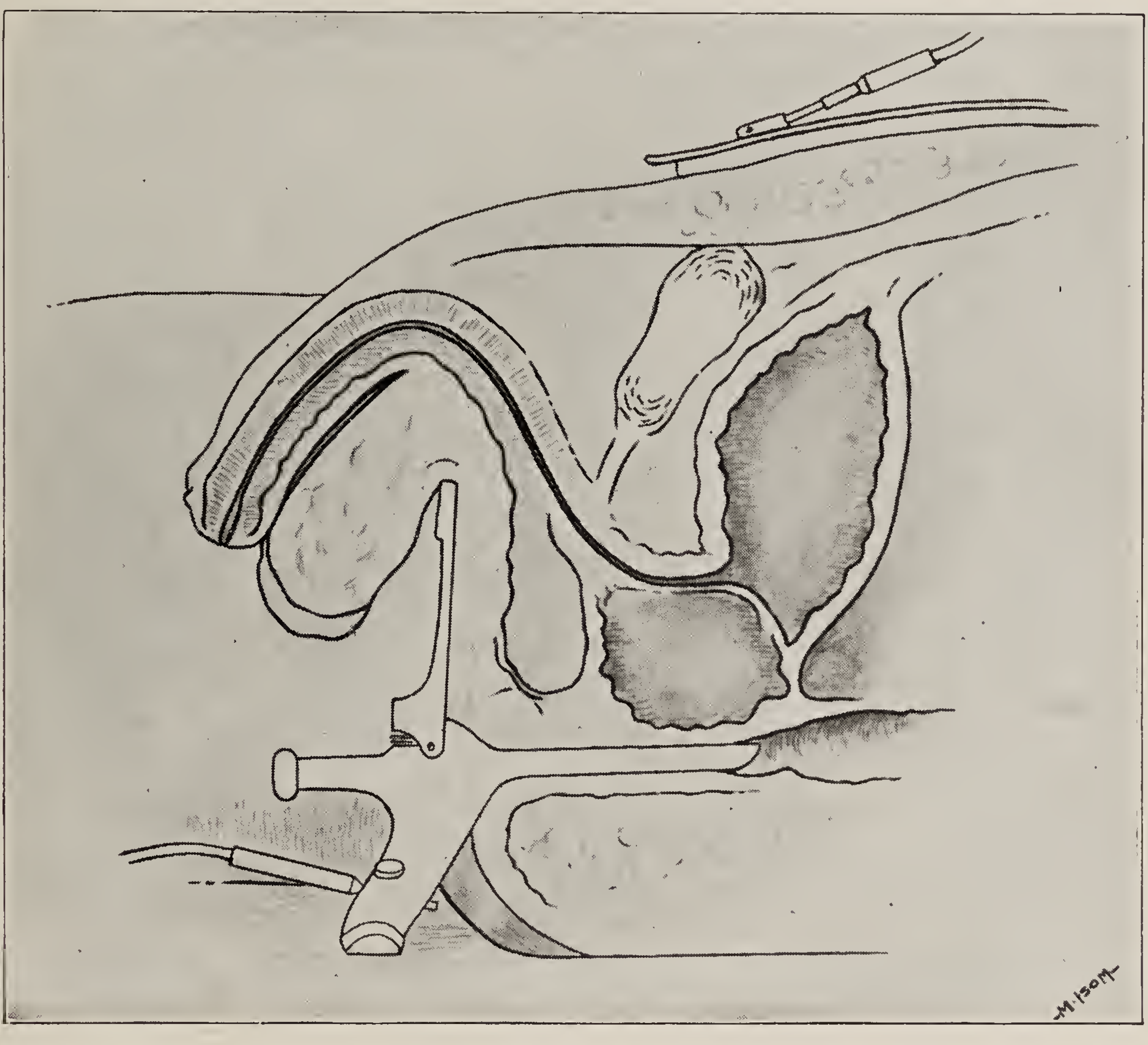

Fig. 2. The author's method of treating cowperitis by means of d'Arsonval high frequency diathermy.

Chronic cowperitis. Beyond question, one of the prime factors to be considered, in attempting to discover the cause for chronicity and obstinance in many cases of long-standing gonococcal infection, is the possibility of a latent focus in the glands of Cowper. For diplococci will thrive in these hidden nooks and corners of the urogenital apparatus where neither medicaments nor the defensive forces of the human organism appear able to cope with the situation. While the lacunæ of Morgagni, the glands of Littre, the prostate and seminal vesicles are usually attended to, these bulbourethral glands not infrequently escape the clinician's observation. This is to be noted especially in the chronic stage of the disease where there may be little or no visible evidence of trouble. Upon bidigital palpation there may or may not be sufficient induration to arouse suspicion. Palpation of many badly infected glands may be impossible because of the obeseness of the patient. We have observed chronic cowperitis in several patients who were so stout, with so much perineal fat, as to make palpatory diagnosis impracticable. Apart from the persistent discharge, disappearing sometimes for weeks, only to reappear again, there may be no other objective symptom of chronic cowperitis. Naturally, where such a gland has previously been incised for abscess formation and where a fistulous tract empties its sero-purulent material on the perineum, a chronic state of infection in the gland proper is to be expected.

Chronic cowperitis may sometimes be observed to undergo acute exacerbations occasioned by excesses or by trauma. It is not necessary that these exacerbations be necessarily accompanied by any subjective symptoms. There may be but persistent repetitions of the urethral discharge which, because of its soiling the undergarments of the patient, brings him to the physician seeking relief.

The treatment of chronic cowperitis will embrace all points in therapy enumerated under acute cowperitis plus the astute employment of deep urethral dilatation by means of the Kolmann dilator, the application of diathermy and the use of foreign proteins intramuscularly given. This latter agent — foreign proteins — will unquestionably raise the leucocytosis and in this way will materially enhance the patient's resistance. The frequently observed reaction or 'protein shock' following the intramuscular injection of milk, characterized by chill, nausea and high fever, seems to materially benefit any type of chronic neisserian infection. Surgical procedures directed at chronic states of infection in the bulbourethral glands have met with little success and are not to be recommended. Vaccines and sera are also worthless. Mechanical dilatation to the bulbous urethral, physiotherapy in the form of diathermy intelligently applied, and the use of intramuscular injections of milk offer the best results in chronic cowperitis. VOL. 3. 930

Tuberculosis. Only one case has come to our attention of primary tuberculosis of Cowper's glands. This case, reported by Papin and Vafiadis[14], was observed in a man of 43, with two fistulous perineal openings at the level of Cowper's glands on the right side, both sinuses discharging seropurulent liquid. Five years prior to the present condition the patient had first noted a whitish urethral discharge free of gonococci. Two years later the right Cowper's gland abscessed, which was opened by means of poultices. Since then a fistula had persisted. The gland was removed en bloc. Microscopic sections revealed distinct tuberculous masses of giant and epitheloid cells which ran from the large canals covered with stratified pavement epithelium, horny, very infected, to the terminations of the fistulæ. The perineal fistula persisted after operation. An x-ray study later revealed a pulmonary process.

In the light of our present knowledge regarding urogenital tuberculosis in general it would seem to be the more prudent plan to temporize more in patients suspected of this type of infection in the bulbourethral glands. A hygienic and dietary regime which would tend to build up the patient's resistive forces would appear more in order. Heliotherapy unquestionably will help these cases. But drainage, cauterization, packing and even the use of tuberculin should be reserved for last.

Calculous cowperitis. The rarity of this type of lesion is attested by the fact that only one authentic case is to be found in the literature. Laquiere and Bouchard[15] recently observed a man of 48 in which the sole complaint was a dull, lancinating pain in the perineum accompanied by evacuations of a cloudy, purulent urine. Upon examination a tumefaction, in the median line and elongated in the antero-posterior direction, formed a distinct prominence which ended in front at the base of the scrotum and behind in the perineal region. Its consistency was hard, woody. Incision over the mass liberated a purulent liquid and thirty small, elongated calculi the size and shape of grains of wheat. The authors explain the formation of these stones as due to a deposition of phosphates in the infected glandular liquid. It is not unlikely that with more attention being directed at these glands in the future, calculi of these bulbourethral structures will not be considered as infrequent as is now supposed.

New growths of Cowper's glands. No cases of benign growth of Cowper's glands are to be found in the literature. Even the malignant growths in bulbourethral glands have been reported most infrequently. Only four instances of cancer are to be located in urological literature. The reported cases found are those of Blanc, Weis and Carret[16]; Kocher[17]; Piertrzikowski[18]; and, Paquet and Herrmann[19]. In all instances the microscopic picture was characteristically epithelial carcinoma. It is claimed that in all these cases pain on defecation was most pronounced while the act of urinating was free of all distress. The urine was uniformly normal in all four cases. These points are considered of importance as differential diagnostic aids. The *prognosis* is most discouraging as metastases to the inguinal glands is usually rapid and recurrence is observed where surgery is attempted. Radium and deep x-ray therapy would find a fertile field in the treatment of cancerous invasion of these structures. The regions to be treated are readily accessible and are so situated that the treatment can always be well under control.

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UROLOGY: ITS EVOLUTION AS A MEDICAL SPECIALTY

BY

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Urology is one of the youngest members of the family of medical specialties. Compared with most of the terms used in this science, the word itself is of very recent origin. Yet urologic procedures were among the first attempts at surgery, and the diseases with which the urologist is primarily concerned are probably almost as ancient as the human race itself. Therefore, to seek the beginnings of urologic history we must go back to the days when men first wrote of medicine.

Undoubtedly, the earliest written records of the art of healing were compilations of oral tradition, infinitely older than any history in the sense in which we now use the term. The most remote of these compilations were made by the Hindus, Egyptians, and Greeks. Which of these is the oldest we have now no means of judging. The written works of Hippocrates, the Greek, long revered as the Father of Medicine, are modern when compared with the Ayurveda of the ancient Hindus or the Ebers' Papyrus recording the medical lore of early Egypt. How far back should be placed the sources from which Hippocrates' medical lore was undoubtedly derived remains a complete mystery to students of medical history. And how much one of these ancient compilations may owe to others still older can be nothing more than a matter of speculation.

A search of any or all of these earliest medical writings brings to light many references to urologic diseases and practice. Often the description of the ailment for which prescription is being given will be so vivid and clear as to be instantly recognizable as one which still afflicts mankind. Again, it is impossible to reconcile the symptoms and course as set forth by the ancient writer with anything known to medical men of the present time. But the search for clues is a most fascinating occupation, and, in common with medical history in general, the history of urology proves itself well worthy of whatever effort we are obliged to make in order to gather it piecemeal from the records of human endeavor in ages long past.

UROLOGY AMONG THE ANCIENTS

Babylonian urologic practices. We have no means of knowing whether the Egyptians or the Hindus were the first to commit their medical practices to writing, but it seems probable that what we know of ancient Egypt is as remote as anything now in our possession. In the University of Pennsylvania's Museum is a tablet of great antiquity, of Neo-Babylonian origin, which contains some urologic prescriptions of much interest. Archeologists, however, assign this to as late as 650–600 B.C., and we have good ground for believing that some of the Egyptian medical writings are considerably older. The recommendations of the physicians who caused their prescriptions to be placed upon the Egyptian papyrus and upon the Babylonian clay tablet are very similar, but whether we are encountering traditional recipes which were derived by one nation from an other and older civilization, or whether we are merely witnessing the working of the same human mental machinery under different guises, there is no sure way of finding out.

The tablet, which is but a fragment, is written in cuneiform, and, as these particular hieroglyphics have only recently become decipherable, its contents are an addition to ancient urologic lore of particular value. In that portion of the text which can still be made out we find eight different descriptions of urinary and genital disease for which some twenty-one prescriptions are, in some cases, appended for the same malady. Many of these vary by but a single ingredient, which would lead one to believe that this fragment represents a compilation from older sources. Most of the ailments listed are readily recognizable; incontinence of urine, vesical calculus, and prostatitis undoubtedly troubled the inhabitants of " great Babylon " of old just as they do those of the lesser Babylons of our own age. The medicaments used, however, are in marked contrast to the methods of the present. A single example will suffice:

> " If a man is sick of stone,
> Thou shalt mix cedar water, cypress, bitter plant, passucane. All these herbs . . . ' the tear of the eye ' thou shalt smear. Thou shalt pour it on the man's sore . . . during pain he will not know. It will restore him. The roat of the cynoglosson he shall eat and he will recover."

Ancient Egyptian urology. Circumcision, the oldest operation upon the genitals of which we have knowledge, was a religious rite, not a procedure for the cure of disease or deformity. This was practiced by all Semitic people, although the impression gained from the Hebrew Scriptures would lead us to suppose that it was peculiar to the Children of Israel. In 1897 the French archeologist, Loret, discovered at Saqqarah a low relief, dating from the fifth dynasty, upon which the operation, or ceremony, of circumcision is clearly portrayed. The first figure shows a young boy whose hands are firmly held by another who is apparently the assistant of the officiating priest. The boy's wrists are grasped and his hands held upward so as to shield his face, presumably so that he may not be obliged to behold the actual progress of the operation. Kneeling before these two is a third figure, evidently a mature man, clothed in a robe, who is engaged in cutting off the youth's prepuce with an oval instrument, a double-edged flint fitted with a handle, a number of examples of which survive to the present. In the second figure, the painful part of the procedure is evidently over, for the assistant has disappeared and the youth rests his hand on the operator's head, though some sort of instrument can still be made out in contact with the severed foreskin. There is nothing about this bas-relief suggesting that it relates to medicine. Rather, it is a passage in the life history of him who lay within the

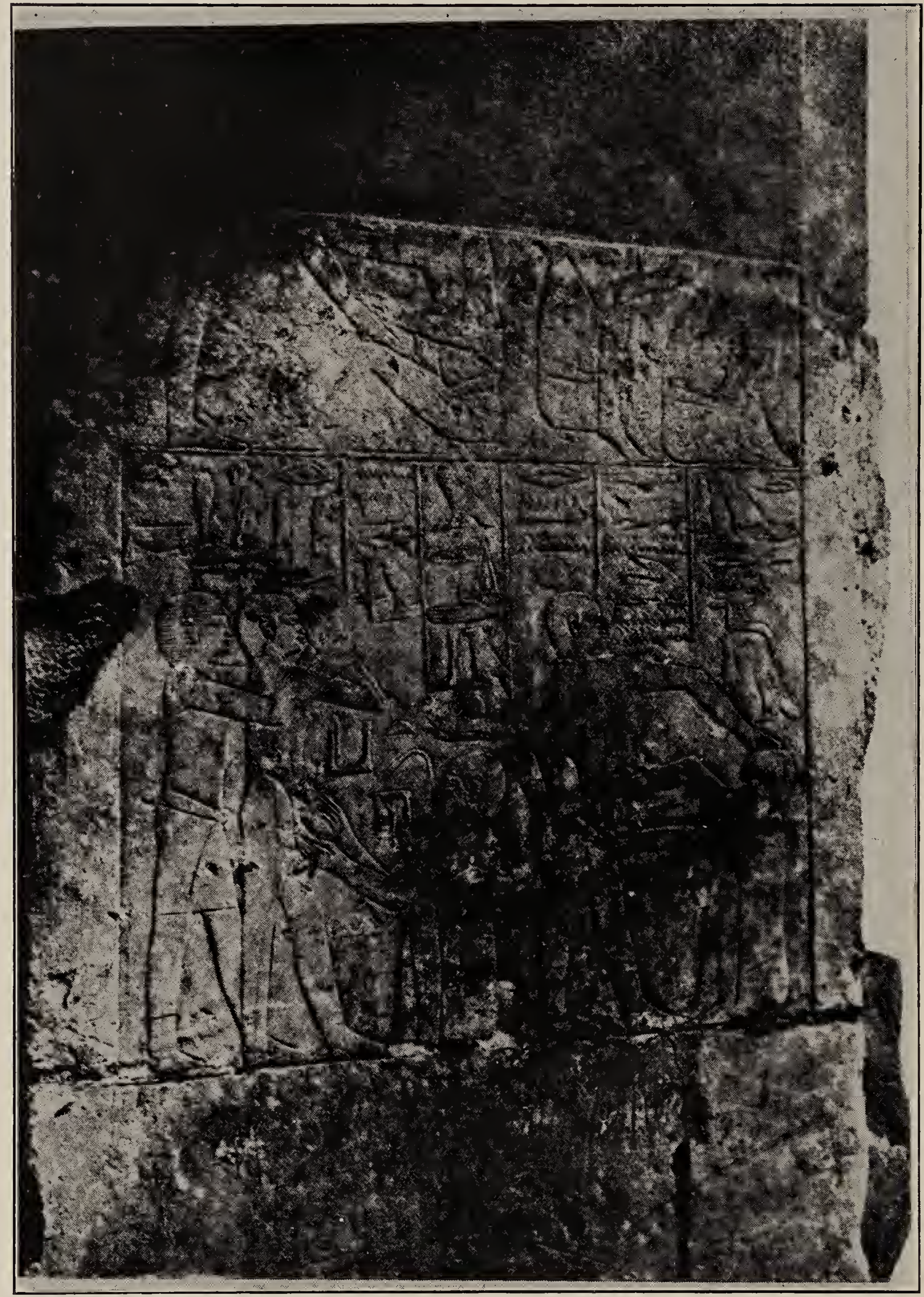

FIG. 1. Ancient Egyptian bas-relief, showing the operation of circumcision. (Desnos)

tomb which it adorned, and was probably the record of a period of rejoicing at the attainment of manhood, as is the custom with the present-day Mohammedans, who perform circumcision at puberty. Several statues of Pharaohs which have been uncovered show the sculptor's representation of the amputated foreskin, and it is generally conceded by students of Egyptology that the rite was reserved for those of the highest social caste.

Of the manner in which those who dwelt in ancient Egypt received medical treatment we have learned a great deal from the Ebers' Papyrus. This is a very ancient hygienic compilation, relating to health in general but containing likewise many prescriptions for individual diseases, those of the urogenital tract among them. This famous source of early medical history is so well known that one hardly need pause to describe it. It lays little stress upon strictly urinary disorders, but certain prescriptions are noted as useful in incontinence, polyuria, and excessive frequency. Though resembling, in a general way, the Neo-Babylonian tablet already mentioned, the manuscript is by no means so detailed as the prescriptions baked into clay, which would thus lend color to the assumption that the tablet is of a later date.

Hindu urology. Even greater than the mystery which surrounds the medical lore of early Egypt is that veiling the beginnings of Indian medicine. Perhaps a thousand years before Christ the first books were written, possibly even earlier. In these sacred books, the Vedas, are recorded the wisdom of that age, and in this collection medical wisdom has an honored place. In the Ayurveda, which is the last but perhaps not the youngest of these books, we find numerous matters treated which are more or less closely related to our special subject. The causes of incontinence and retention of urine, for example, are discussed at considerable length. A careful consideration of the descriptions of diseases which the editor of this compilation has set down often enables us to recognize their modern counterparts. *Madhumoha*, " honey urine," at once suggests diabetes mellitus, even if we were not also supplied with the descriptive symptoms — languor, thirst, and bad breath; and several similar maladies are equally recognizable. In some later writings of the Hindus, which borrow freely from Sucruta, whom we are accustomed to call the ' editor ' of the Ayurveda, we find more concerning urinary diseases, their etiology and treatment. Herein we learn that all such affections arise from three causes — phlegm, bile, and vapors. Ten ailments which render urine watery, sweetish, thick, sandy, slimy, saline, purulent, oily, intermixed with seminal fluid, or effervescent (I translate freely from Desnos) are attributable to phlegm. Bile is responsible for six more diseases of the urinary tract, while to malign vapors can be traced the origin of four incurable affections.

Calculus disease was evidently well known in India, in marked contrast to Egypt where no mention of anything resembling stone is to be found in the early writings and where no evidence of any such operations can be seen upon the bodies of the many thousands of mummies which have been examined. Diabetes seems also to have been common and to have caused some perplexity in regard to treatment. Prescriptions for controlling the urine and influencing its composition are exceedingly numerous. The instruments, of which the appearance and use are described at length, are apparently useful predecessors of our sounds, trocars, catheters, and even rectal specula. Actual cutting operations for the correction of hernia and the removal of stone are set forth in detail. The etiology of lithiasis is dwelt upon at length and the manner of its removal fully discussed. Without much trouble one may pick out a recognizable symptom-complex, thought by these ancient clinicians to be attributable to alterations in the urine, which they evidently scrutinized with diligence. They also appear to have known that pain was oftentimes referred from its actual site to some related organ, and also to realize that pain, in the testicles for example, might actually be due to the presence of a stone in the bladder some distance above.

Like all ancient hygienic treatises, much superstition and meaningless jargon is mixed with the professedly medical lore, but now and again there crops up something which speaks to us from these far-off times as the voice of a man who was really a physician, who used eyes, ears, brain, and heart in ministering to his patients, and found within himself much greater wisdom than his forebears had ever written down.

Desnos's account of ancient Hindu instrumentation is made up from Hessler's translation. Urinary surgery was definitely recommended and practiced. The *Instrumenta tubulata multipliciter adhibenda* of Hessler's translation this author believes to be the sounds used by these early practitioners for relieving retention in the urinary bladder. When the overfilled bladder made a tumor to appear in the abdomen, its cause was recognized and measures instituted to draw off the urine; when the scrotum was the site of such a tumor, it was punctured and the fluid withdrawn through a trocar. The scrotal tumor was first treated by hot applications, and instrumentation resorted to only when lesser measures failed. There is some confusion in the translator's mind as to whether these ancient physicians distinguished between vesical obstruction and hydrocele, but the mere fact of their having the hardihood to operate upon such conditions is of interest to the student of medical history.

As the inhabitants of India to-day suffer greatly from urinary calculus, it is not surprising to find that much of their early medical work was directed toward the mitigation of the suffering caused by this complaint.

It is recommended that the stone be made to pass, if possible, by internal medication and the use of poultices upon the overlying skin. If the stone could be palpated, hooks and crochets were to be passed to it, if it chanced to lie within reach of these instruments. If it did not, and it was evident that the sufferer could not long survive unless relieved, it was permissible to cut down upon it, but this was understood to be extremely hazardous, and to be undertaken only when all other hope had departed. Then, if all the omens be favorable, the patient disembarrassed of evil spirits by the proper exorcisms and suitable religious ceremonies duly completed, the physician should begin by offering all possible encouragement to the sick man. He should then seat him upon a suitable operating bench and securely tie his arms and legs. The abdomen is to be anointed with oil and strong pressure exerted upon the left side of the umbilicus until it is possible to palpate the stone. The surgeon's finger, with nails well trimmed and thoroughly lubricated, is now introduced as far as possible up through the anus, while the other hand endeavors by external pressure, to approximate the reach of the internal fingers, so that the stone may be pushed downward toward them. If the operator can thus touch the bladder, the stone may be shelled out as one would a nut. Should the patient lose consciousness when the calculus is attained, it is useless to continue the effort for he will surely die. But if his fortitude be sufficient, the extraction may be happily concluded. An instrument proportionate to the size of the calculus is now selected to make a small incision. Through this the stone is withdrawn by means of pincers. The greatest care must be exercised not to break or even to scratch the stone. Should the slightest grain of dust from it remain in the wound, it will form a nucleus for another stone. Once the extraction is over, the patient should be placed in a warm bath, and other measures instituted to induce profuse perspiration.

Admonitions to the surgeon are not lacking as to the necessity of selecting a site for the incision which will avoid injury to adjacent organs. Should he cut the source of urine (i. e. the ureter) death will inevitably follow. If the spermatic canal is severed, impotence surely and death probably, will be the result. Virility will be lost if the testicles are injured, and damage to the urethra means that incontinence of urine will result. In later pages we shall refer particularly to the history of lithotomy, and these details from the most ancient people who are known to have practiced it are of peculiar interest in this respect.

Biblical urology. Some antiquarians have been at considerable pains to scan the pages of the Bible and extract therefrom all references to things medical, the urological among them. As a matter of historical record, most of the ancient Hebrew urologic practice, if it can be dignified by such a title, is contained, not in the Scriptures, but in the Talmud, the Book of the Law, as opposed to the historical and theological compilation which we call the Bible. The outstanding difference between the Children of Israel and the other Semitic tribes is the greater attention to hygiene given by the law of Moses. The practice of medicine, as we are now accustomed to think of it, began with the Jews. The Hebrews undoubtedly had greater opportunities for the study of anatomy through the requirement that all animals slain for food must undergo rigid inspection. Even if human dissection was forbidden, the analogies between man and animals are sufficiently close and numerous to make these postmortem examinations of practical benefit to those wise enough to profit by them. Yet we do not find the Hebrews *treating* diseases of the urogenital tract so much as promulgating rules by which such diseases may be recognized when found, and avoided if possible. That they knew of gonorrhea is practically certain; that they recognized stone and urinary retention is highly probable. There is no evidence that they ever performed any surgical operations for their relief. Circumcision was with them, as with the Egyptians, a religious rite. So we must await the Middle Ages before we see the Hebrews rising to the preëminent position in the world of medicine which has since been theirs.

Greek and Roman urology. At least one volume had been written on Greek medicine before the age of Hippocrates, but the fact remains that it is with him that Greek medicine truly began. That the 'works' of Hippocrates are the accumulated medical wisdom of previous ages is hardly open to dispute, but this in no way lessens their value or diminishes the immense influence they have had upon medical art and practice from the days of Greek greatness even until now. In this vast system of medicine, urology received a certain amount of attention. More than three hundred years before the birth of Christ the Father of Medicine described urinary calculus and even hazarded a very intelligent guess or two as to its origin and pathologic effects. His oft-quoted statement has, however, come down to our own time: "I do not cut for stone. That work I leave to those who have received special training for this employment." From these words we cannot but apprehend that he considered the practice of surgery unworthy of him who followed the physician's calling. The Greek reverence for the physical body and their horror of mutilation, even after death, were no doubt responsible not only for their position in regard to surgical operation but for a really deplorable lack of anatomical knowledge, which could not be acquired without actual investigation of the human structure and tissues. Yet Hippocrates must have given much serious study to renal diseases and has left us some detailed descriptions, portions of which are readily identified with conditions familiar to every modern practitioner. His suggestions regarding diet and hygienic procedures are quite as sound and applicable now as they were in the days when they were first committed to writing.

Roman medicine, like the great bulk of all Roman culture, was derived directly from the Greek. Therefore, we find in the works of Celsus, the first notable Latin writer upon medical subjects, little more than repetition and slight, very slight, amplification of what Hippocrates had taught some three hundred years before. Celsus was not himself a physician. For this reason, perhaps, he includes in his observations and descriptions of things medical several surgical procedures such as lithotomy, the correction of phimosis, and the relief of strictured urethra.

Among the most interesting mementoes of Roman urology which have survived into our time are the votive offerings at the shrines of Hygeia and other deities supposedly influential in restoring or preserving health. A custom persisting from the most remote antiquity manifested itself by the presentation at the selected shrine of models of the anatomical parts involved in the disease. Thus, archeologists have dug up about the temples of Æsculapias and Hygeia vast numbers of representations of the human generative organs, particularly the penis. These were doubtless offered occasionally as a thank-offering for offspring or possibly as a prayer that offspring might be granted. But among these images many have been found which surely represent diseased conditions — such as phimosis, and balanitis. The prepuce is shown distended and ulcerated so often that it furnishes a fair index to the prevalence of venereal disease at that period of history. One terra-cotta figurine has been found which shows a scrotal tumor, presumably hydrocele; the engorged bladder has been carefully indicated by the sculptor, and the whole representation is almost startlingly realistic.

Archeology has also furnished us with information concerning urologic practices among the ancient Romans by bringing to light some of the treasures concealed for eighteen hundred years in the ‘physicians’ house’ buried under a mountain of lava at the destruction of Pompeii in the year 79 A.D. Among the many instruments found there are several sounds, one of which, the largest, has a double curve such as is frequently made use of at the present day. This implement is fashioned out of bronze of extremely light weight, and so well has it been preserved that some of the original polish still shows upon it after almost two thousand years. Another sound is pierced at its tip by numerous holes, and one may surmise that it was designed for use in cases of vesico-vaginal fistula.

Still another, without a tip, was in all likelihood employed in operations on female patients.

ARABIAN MEDICINE

With the destruction of the Roman Empire and the decline and disappearance of most of the arts of civilization, medicine, in the sense in which we understand the term, was nearly extinguished. But the writings of Galen, last of the great Greek physicians, were in great part preserved in the Byzantine cities, and thence his prestige and practices travelled eastward into that part of Asia destined later to become the empire of the Mohammedan caliphs. The physicians of this period, when all learning was declining, did little more than comment on and rewrite the original compilations of the Greeks who had preceded them. Thus, medicine made no progress for many centuries, and the treatment of urogenital pathology shared with all other branches of the healing art in resort to charms and magic formulæ instead of the patient study and intrepidity which so frequently appear in the literature which has come down to us from the physicians of classic antiquity.

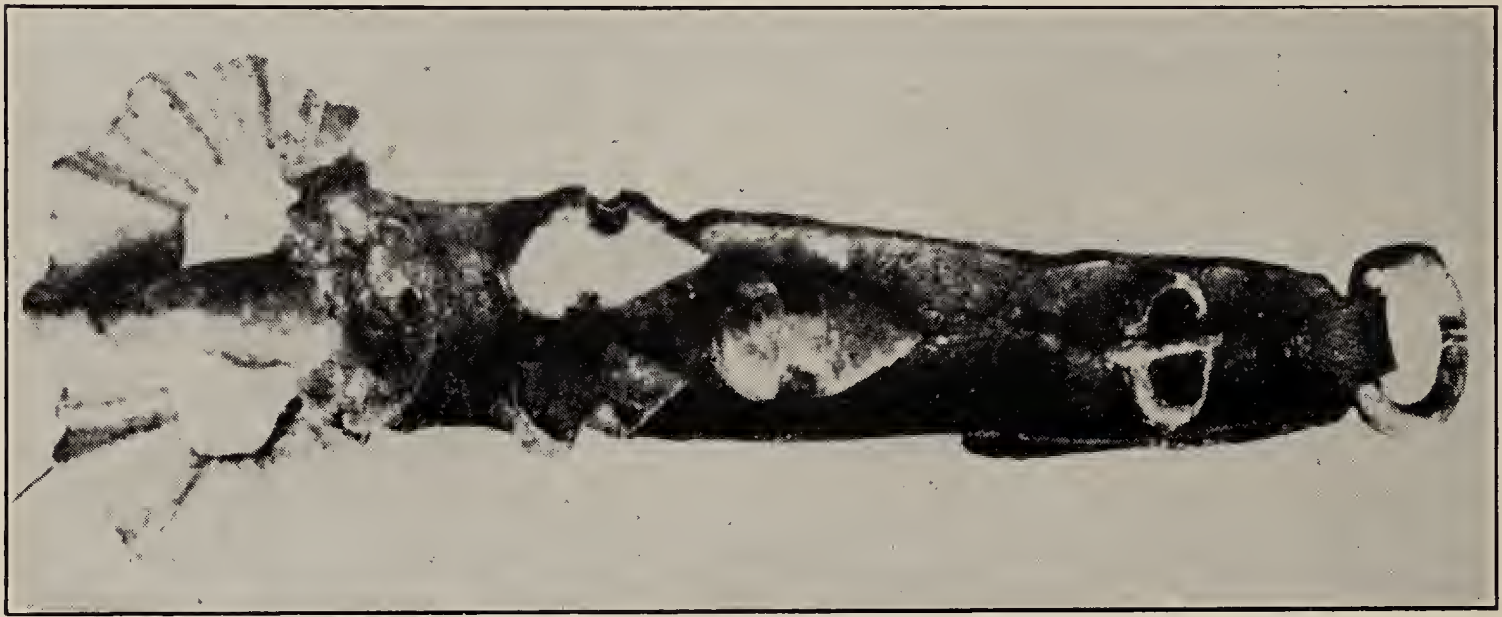

FIG. 2. Inguinal hernia truss made of iron; found at Devise, France, in the burial ground of the Carlovingian epoch; probable date about 450 A.D. From *Les bandages herniaires*, V. Deneffe, Anvers, 1900. (Library of the New York Academy of Medicine.)

One of these "torch-bearers of knowledge," as Garrison calls them, was Oribasius, friend and physician to the Byzantine emperor, Julian the Apostate. He expounded the works of Galen and seems to have practiced somewhat in the mode of the days of Rome's greatness. A description of urethrotomy as he practiced it has been preserved to us through the writings of Aetius, who lived two hundred years later, in the sixth century, but whose copyings from the older physician now furnish us with material which has been hopelessly lost in the original. The last of the Byzantine-Greek eclectics and compilers was Paul of Ægina, and in his writings, collected toward the close of the seventh century, are to be found descriptions of operations, among which are lithotomy and herniotomy. Because he recommended that the testicles be removed in the performance of the second procedure, Garrison credits him with perpetuating this needless mutilation, as his dictum was followed by the Arabians and " continued to be in vogue with the outcast medieval surgeons until far into the sixteenth century." A treatise on the urine was written by Renatus, a ' horse-doctor ' principally remembered because he was the author of the first authentic account of glanders. He was a contemporary of Paul of Ægina. He accepted the pronouncement of Galen that the urine is a filtrate of the blood secreted in the portal vein and vena cava, and this same conception was destined to remain prevalent for many centuries and gave rise to the pseudo-science of uroscopy, much celebrated in song and writing in a later age.

Through contact with these medical men of the end of the classic period, the tribes which gave allegiance to that God whose prophet Mohammed claimed to be came into possession of much of the medical lore of the Græco-Roman period. The doctrines of Galen, strangely distorted though they were, held sway over the Arabian mind, in so far as it was concerned with things medical, for upward of a thousand years. It is not until the eighth century that Arabian medicine gives any signs of originality. Browne cites five writers of the Golden Age of Mohammedan civilization, the oldest of whom was Ali Ibn Rabban, a native of a Persian province south of the Caspian Sea. The greatest work of this scholar — for he was not only a physician but learned in all the sciences and philosophy of his day — is the *Paradise of Wisdom*. This is divided into numerous *Discourses*, one of which — Discourse IX — treats of genito-urinary diseases, their diagnosis and treatment. The second of the quintet of learned Arabian physicians was he whom the medieval Latinists called Rhazes, or, in Arabic, ar-Razi, from his birthplace, Ray, an ancient Persian city. He was a physician of very high repute and is said to have written something like one hundred and thirty works on a wide variety of subjects, although the majority of his literary productions dealt with matters more or less related to medicine. A monograph on renal and vesical stone was published at Leyden in 1896, this being the first time it had been made available outside the early Arabic manuscript. This contains the Arabic text and a parallel French translation. It represents one of the oldest — if not, indeed, *the* oldest — monograph on stone in the kidney and bladder. The third eminent Arabian medical man mentioned was Avicenna, probably the best-known physician of the Mohammedan era. In his works are many references to urogenital diseases, but what he wrote was largely compiled from earlier writers,

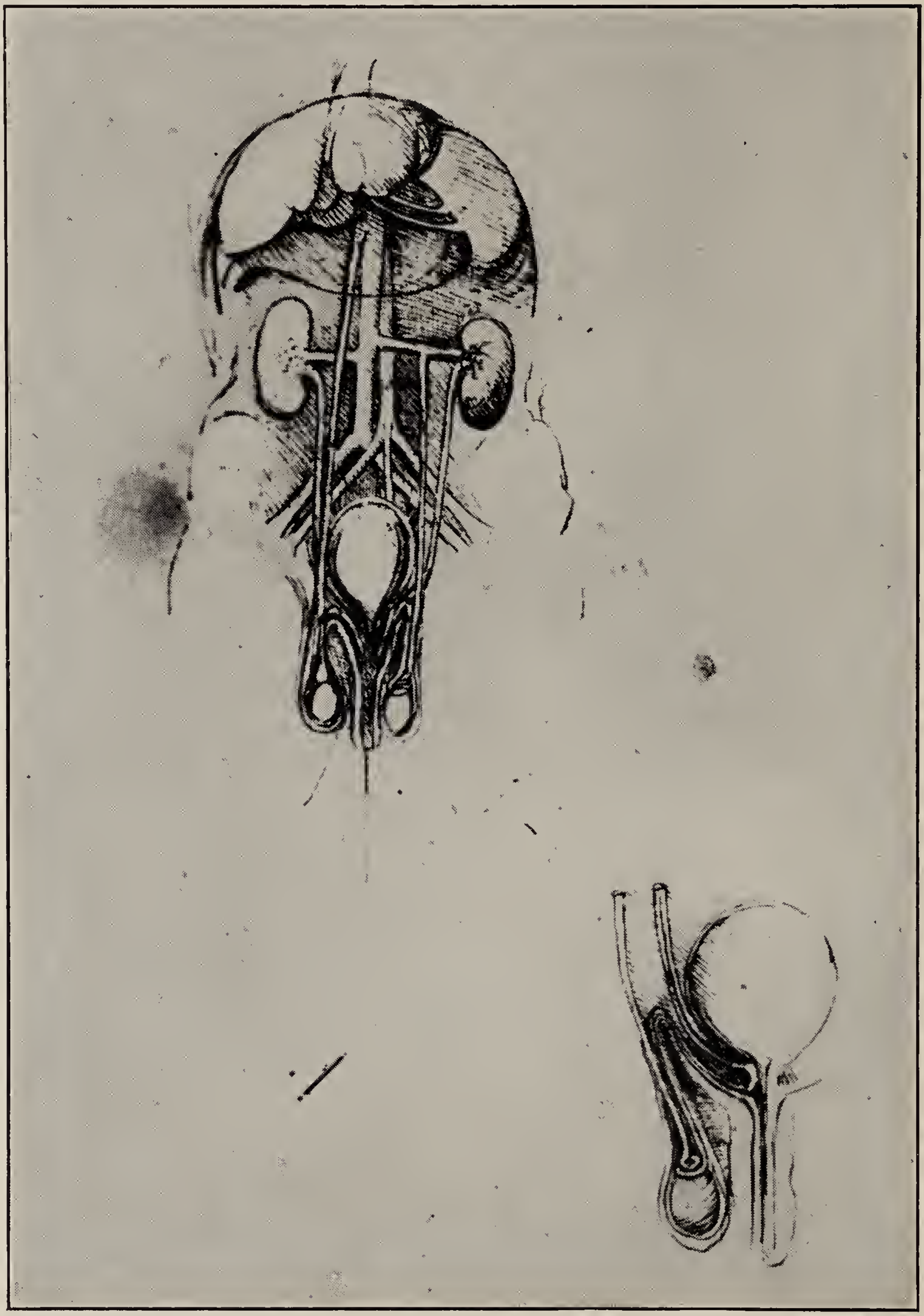

FIG. 3. Leonardo da Vinci's conception of the male genito-urinary system (circa 1490). From *Quaderni d' anatomia*, Folio III. Reproduced from the original in the Royal Library of Windsor, by J. Dybwab, Christiania, 1913. (New York Academy of Medicine Library.)

notably the Greeks, and added nothing to the sum of knowledge concerning our special subject. The same is true of the other writers cited.

Yet it was these men who, with their disciples and successors, " now took (to employ the words of Withington) from the hands of unworthy successors of Galen and Hippocrates, the flickering torch of Greek medicine. They failed to restore its ancient splendor, but they at least prevented its extinction, and they handed it back after five centuries burning more brightly than before." Through the establishment of the great School of Salerno, the most celebrated medical center of medieval times, to which Arabic teachers came to instruct European students, the teachings of Hippocrates and those who had been his immediate successors gradually filtered back toward the land where they had originated, and marked out the channel along which the fresh stream of Renaissance intelligence soon had opportunity to flow.

THE MIDDLE AGES

The fall of ancient civilization in Europe, and the extinction of all culture during that period which we call the Middle Ages, included medicine with the other arts. In the Occident, for many centuries, all scientific advance was swallowed up in superstition and gross ignorance. Surgery was rated as the lowest of all professions; its practitioners were barbers and bath-keepers when they were not hangmen, or followers of other ostracized occupations which afforded opportunity for anatomical and pathological observation not offered by professions more highly considered. Medicine was in the hands of the monks, who relied mostly upon the curative properties of holy relics and oft-repeated prayers. Now and again, however, they made use of decoctions of roots and herbs, thus laying the foundations of modern pharmacology.

The one urologic procedure which persisted throughout this dark period was " cutting for stone." We have seen that Hippocrates held this as unworthy of the skill of a real physician and relegated it to those whose business it was to attend to such matters. This same attitude persisted through the decline of Greece and the destruction of Rome; during the entire period in which the Christian Church rose from humble beginnings to its position as the most powerful single influence in the civilized world; through the vicissitudes of the Crusades and the fall of Constantinople. Not till the invention of printing and the general dissemination of knowledge and the increase in intelligence which accompanied it, was the surgeon regarded as something higher than the most menial and lowly of those who ministered to the comfort and physical needs of their fellow-men. Yet the necessity to " cut for stone " was always great. The very physicians who most looked down upon the lithotomists were obliged to seek their services if the dread malady laid hold upon them.

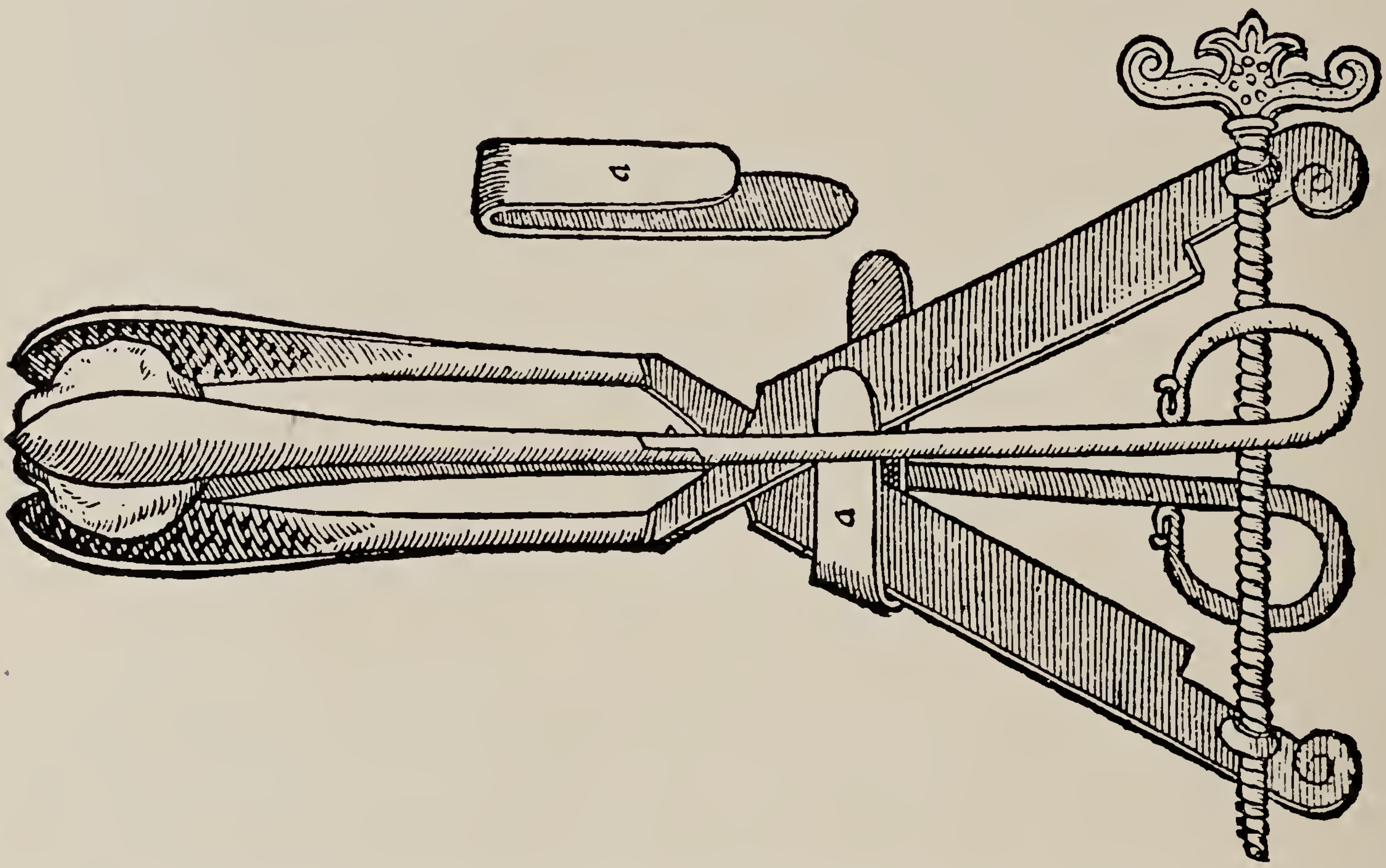

FIG. 4. *Les lateraux* of Ambrose Paré; a combination dilator and grasping forceps. (Desnos)

MEDIEVAL UROLOGY

The written works of the medieval period contain little in regard to cutting for stone, because the learned men who were able to write looked down upon this work and considered any mention of it degrading. Gilles de Corbell wrote a poem on the urine somewhere toward the end of the twelfth century, and Guillaume de Salicet, who followed closely after him, recognized and described certain lesions appearing about the penis and scrotum, and made suggestions for their treatment. The first-named gave no attention to lithotomy, but de Salicet goes into considerable detail concerning the manner of its performance and mentions that nothing save rectal exploration can permit one to arrive at a correct diagnosis. But he gives no indication that he had ever undertaken the intervention himself.

As medical science slowly revived from its age-long lethargy, Italian and French physicians worked in close accord. The immediate successor of de Salicet was Lanfranchi, the Milanese, but his contemporary and ardent follower was Henri de Mondeville, teacher of anatomy at the University of Montpelier. The French anatomist wrote a treatise on surgery, although it may very well have been theoretical rather than the result of clinical experience. From this rare manuscript we are now able to discern something of the medieval medical student's conception of the arrangement of the genito-urinary organs. Henri de Mondeville appears to have been a person of rude manners and possibly was not so far removed from the despised "cutters for stone" as the physicians of his time wished to hold themselves. The only other medical man worthy of the name of surgeon appearing at this time is Guy de Chauliac, whose life opened with the fourteenth century. He, with his own hands, did operations for hernia and for cataract, but he still held himself above lithotomy. Nevertheless, Guy's *Chirurgie* remained for centuries the only valuable treatise on this subject, and lithotomy continued in disrepute.

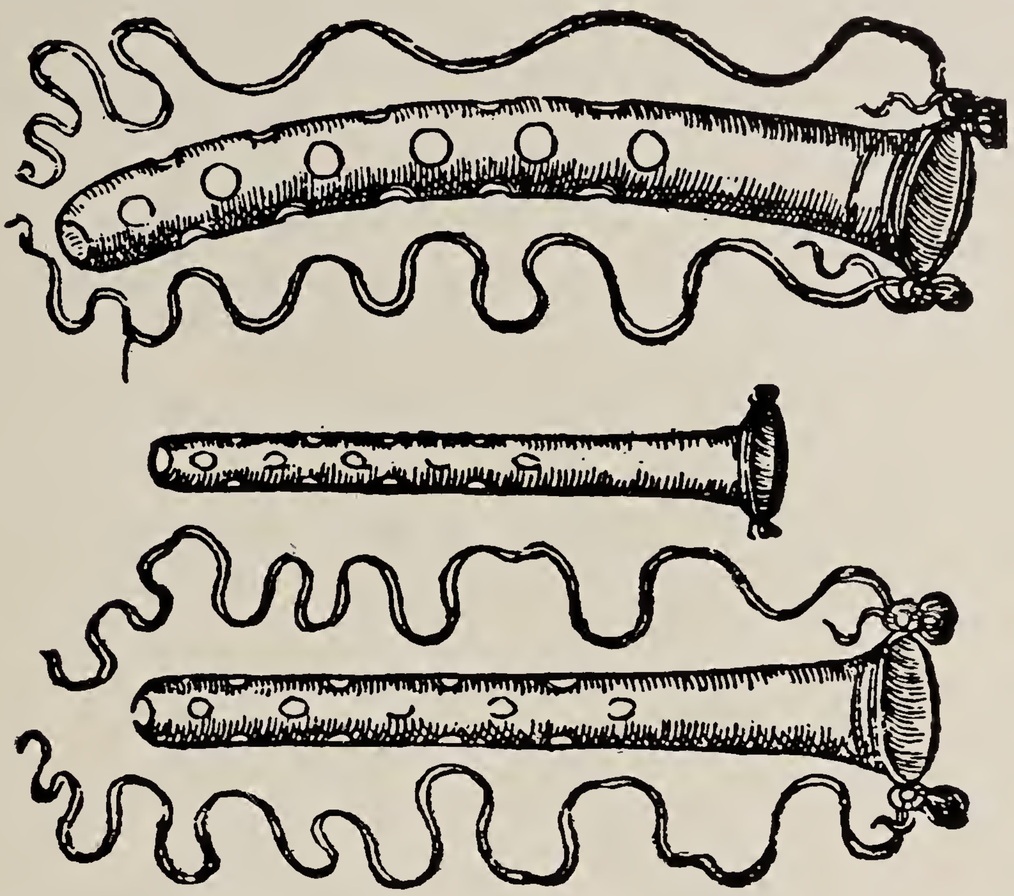

Fig. 5. Paré's perineal cannulas, introduced for perineal drainage after the stone had been removed. Paré did not perform lithotomy himself; it would have been beneath his dignity as a physician. He was willing, nevertheless, to advise those who did perform it. The description of instruments and procedures are given in his *Chirurgie.* (From Desnos)

LITHOTOMY

Of the beginnings of cutting for stone much has already been told in the preceding pages. During the Middle Ages it was the practice of those who followed the profession of wound dressing and minor surgery in general to wander about from one town to another, possibly following a definite route like the tin-peddlers of modern times, but more likely, after the manner of vultures, attracted by news of private or public warfare or other situations in which their special ministrations might be welcome. Cutting for stone was the most serious intervention generally undertaken,

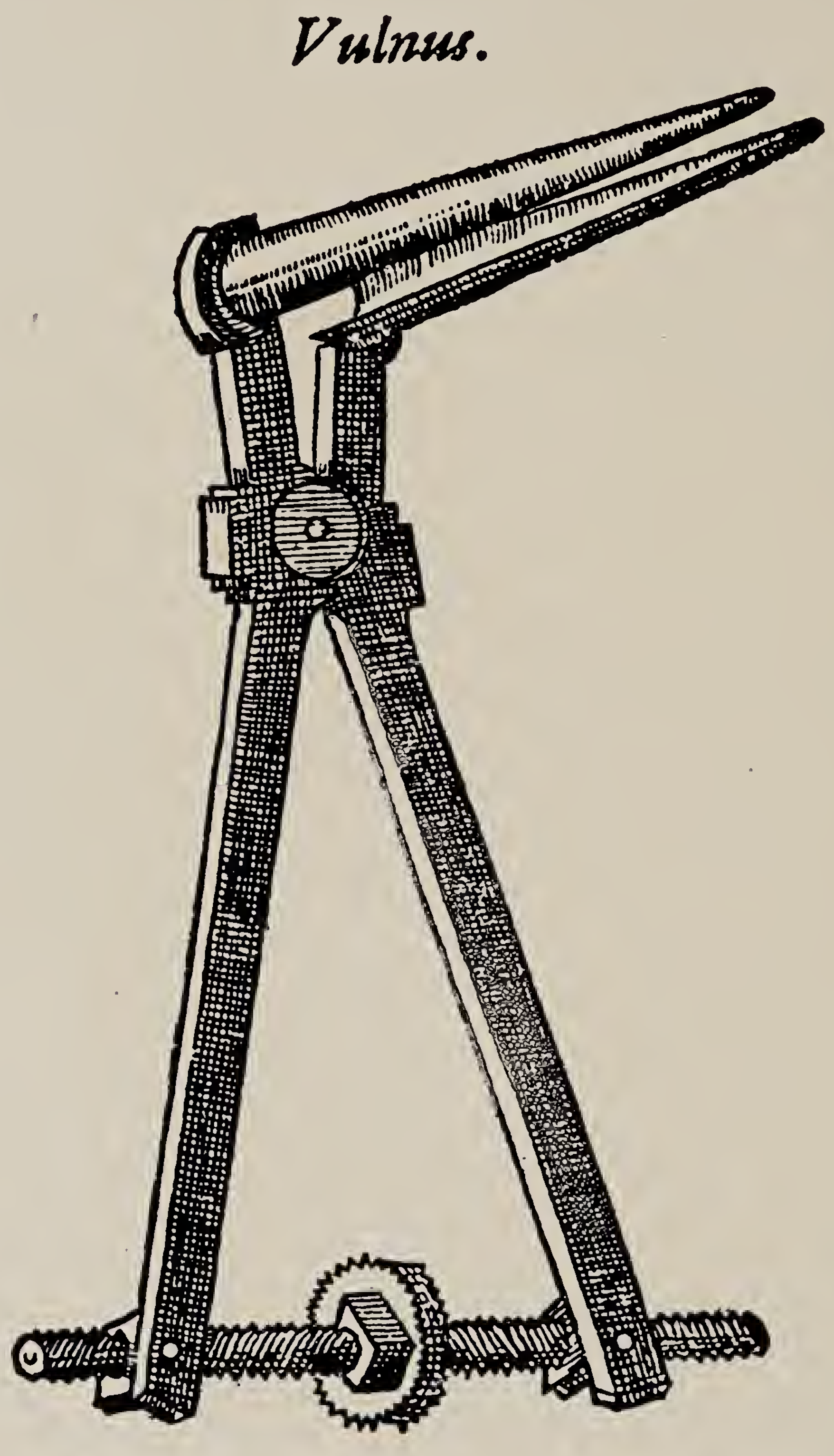

Fig. 6. Fabrice de Hilden's vesical speculum. (Desnos)

and there is no doubt that certain individuals attained a considerable skill in performing it. The lithotomist was looked upon as the social superior of him who merely set bones and dressed surgical wounds, and the secrets of the trade were carefully guarded in certain families much as the Chamberlaines, later in England, guarded the secret of the obstetric forceps. Certain of these families became famous throughout Europe, and were summoned long distances to operate upon wealthy and dis-

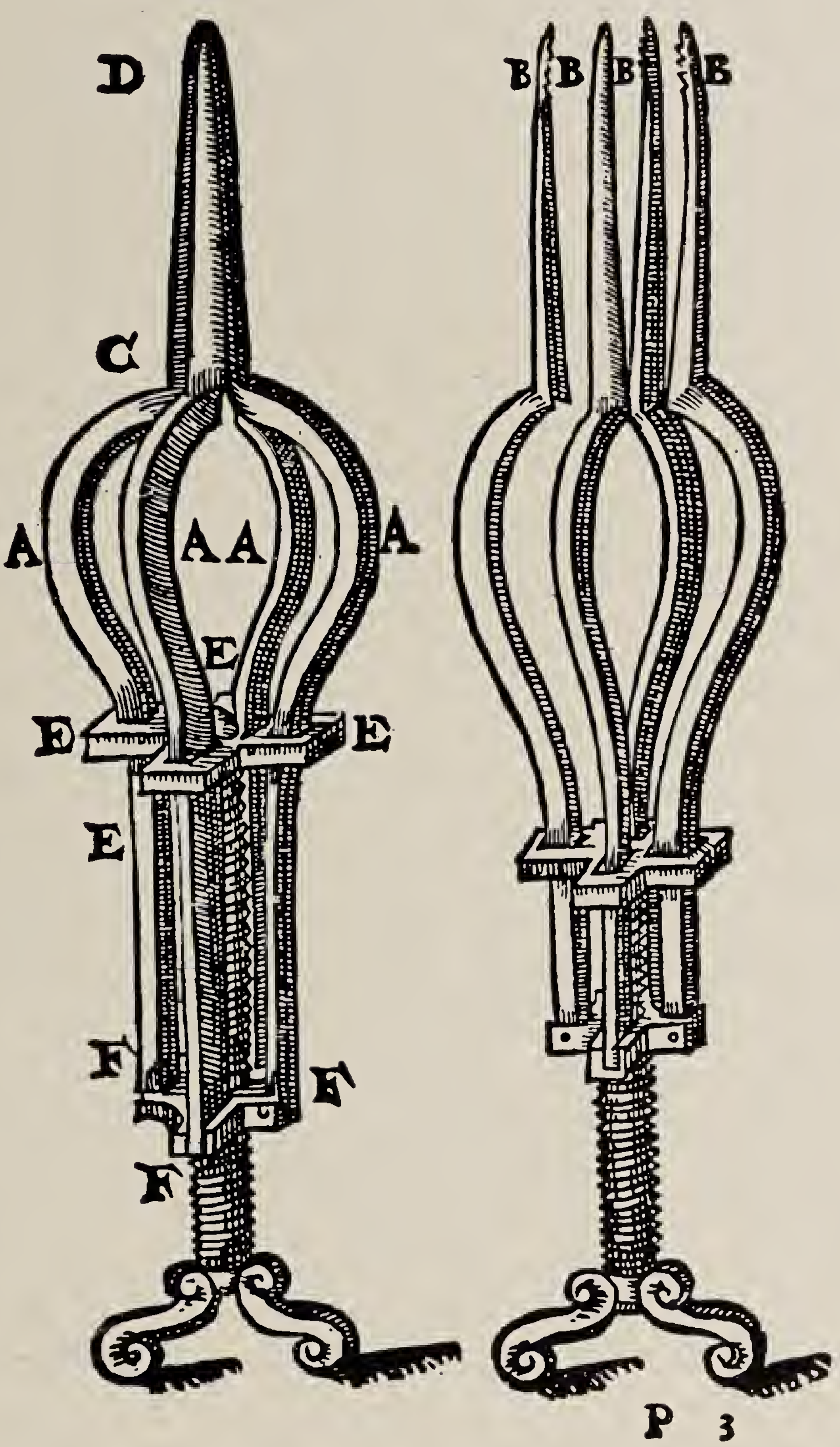

Fig. 7. Fabrice de Hilden's dilator — shown closed as inserted, and open as after operation. (Desnos)

tinguished persons. Naturally, these really skilled practitioners struggled continuously to be recognized as members of the medical profession in good standing, but it was many years before they were able to accomplish this. In the meantime, however, the physicians had begun to take over some of the hitherto despised surgical interventions, and certain of those who began merely as barber-surgeons succeeded by their own efforts in raising themselves to positions of considerable eminence. Chief among

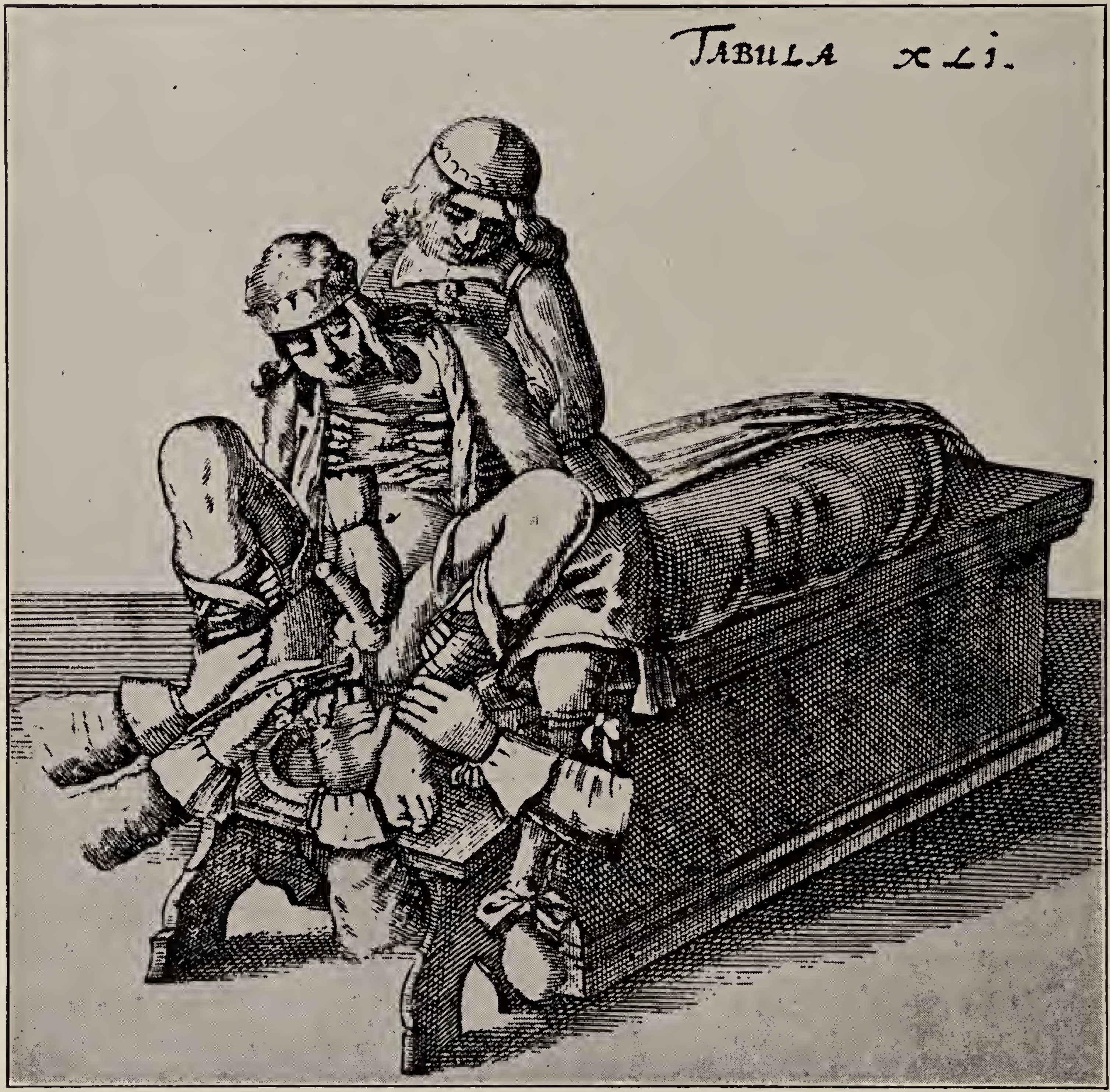

Fig. 8. 'Le petit appareil' — the lesser operation for stone; *i.e.* fewer instruments were used in performing it. This was the procedure described by Celsus as used in the Roman era and practiced in Europe until the middle of the eighteenth century. (Desnos)

these was Ambrose Paré, of whom we shall later have occasion to speak again.

Francis the First, and his successors upon the throne of France, extended their protection to the down-trodden barber-surgeons, so that from the beginning of the sixteenth century onward they began to receive some recognition as practitioners of an honorable profession. The surgeons finally were able to separate themselves from the barbers, and in England and other countries formed themselves into distinctive guilds. Among these, those who cut for stone took a foremost rank, and the medical chronicles of the time now begin to give some attention to this long-despised operation as a measure of therapeutic importance. In the year 1535 there was published at Venice a treatise on lithotomy — the *De Lapide ex Vesica per Incisionem Extrahenda* of Marianus Sanctus. This marked the beginning of what came later to be called the 'grand appareil' in contradistinction to the 'petit appareil,' which was the simple incision for the removal of calculus which had been practiced from time immemorial, and was undoubtedly the procedure to which Hippo-

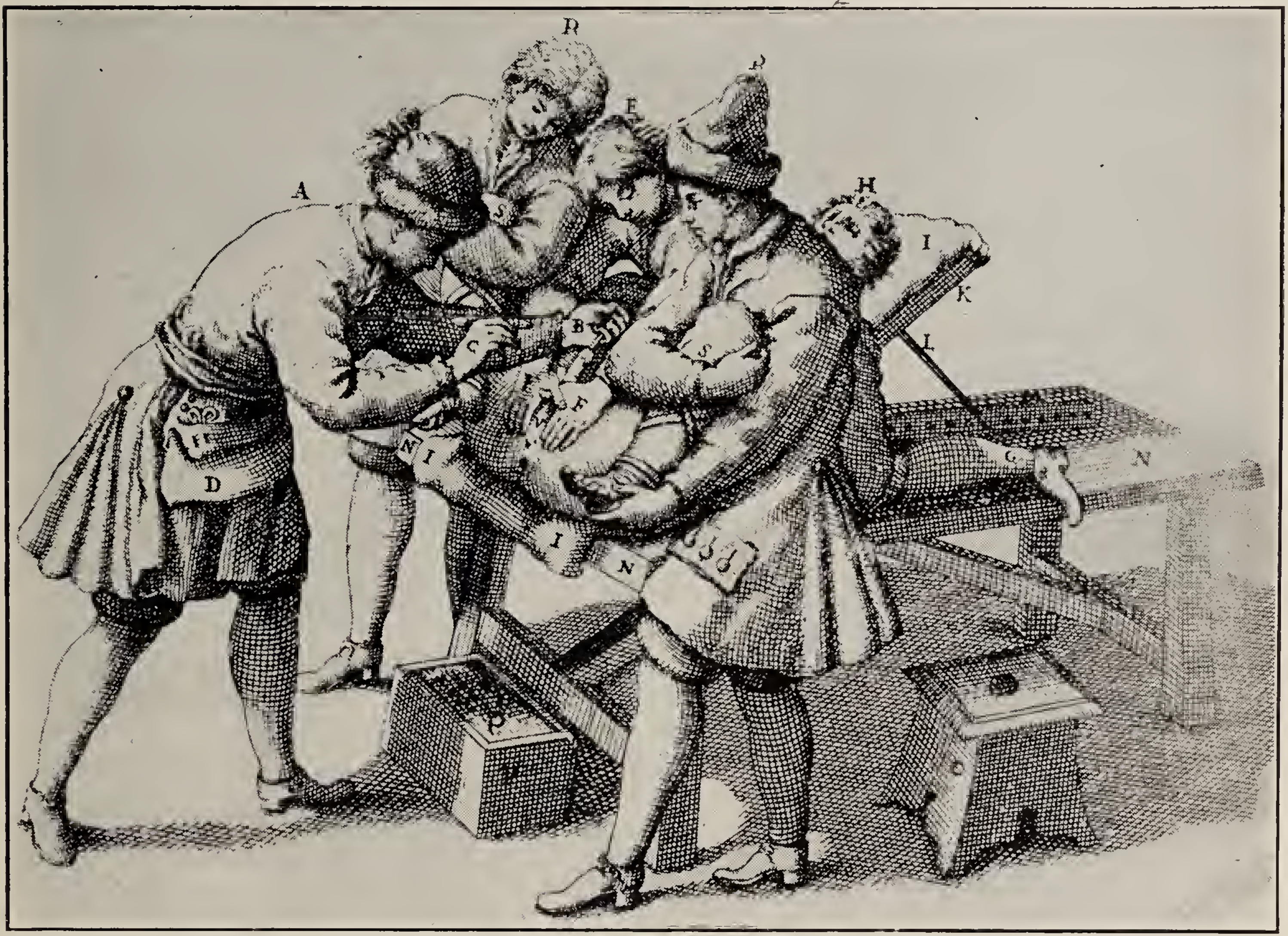

Fig. 9. 'Le grand appareil' — the greater operation for stone, as depicted in Alghisi's *Litotomia*. (Desnos)

crates made reference and which was described by the author of the ancient Veda of the Hindus.

The method thus first committed to writing in the sixteenth century was that of Giovanni di Romanis, an Italian anatomist and teacher dwelling at Cremona, who was apparently the first to use the grooved staff, which made the procedure far more accurate and less fraught with

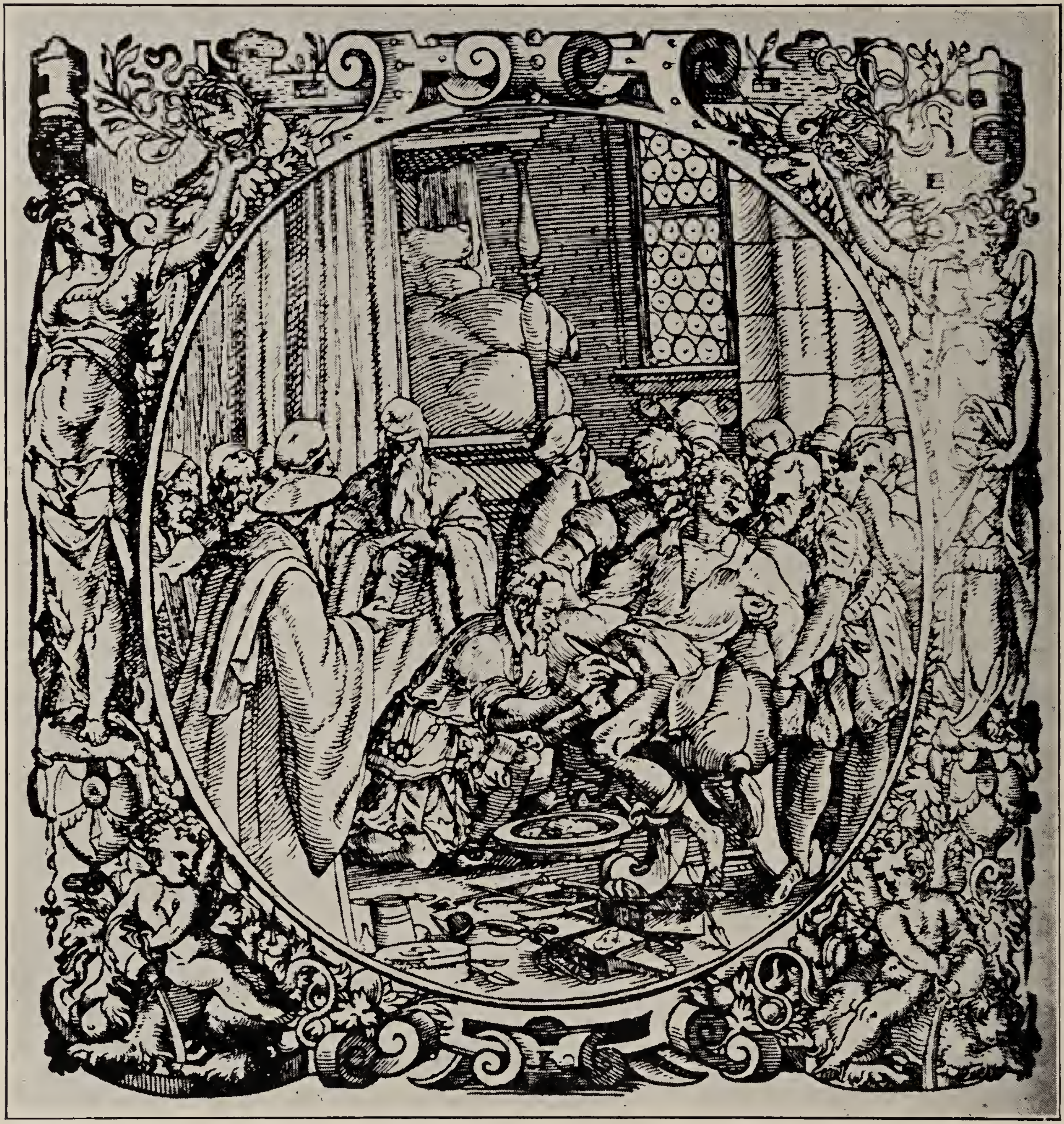

FIG. 10. Paracelsus operating for stone. 'Le grand appareil.' From his *Wund und Arzeneibuch*, Frankfurt, 1566. (This and many of the other illustrations are copied by permission from E. Desnos, *Encyclopedie d'Urologie*, Vol. I, Paris, 1914.)

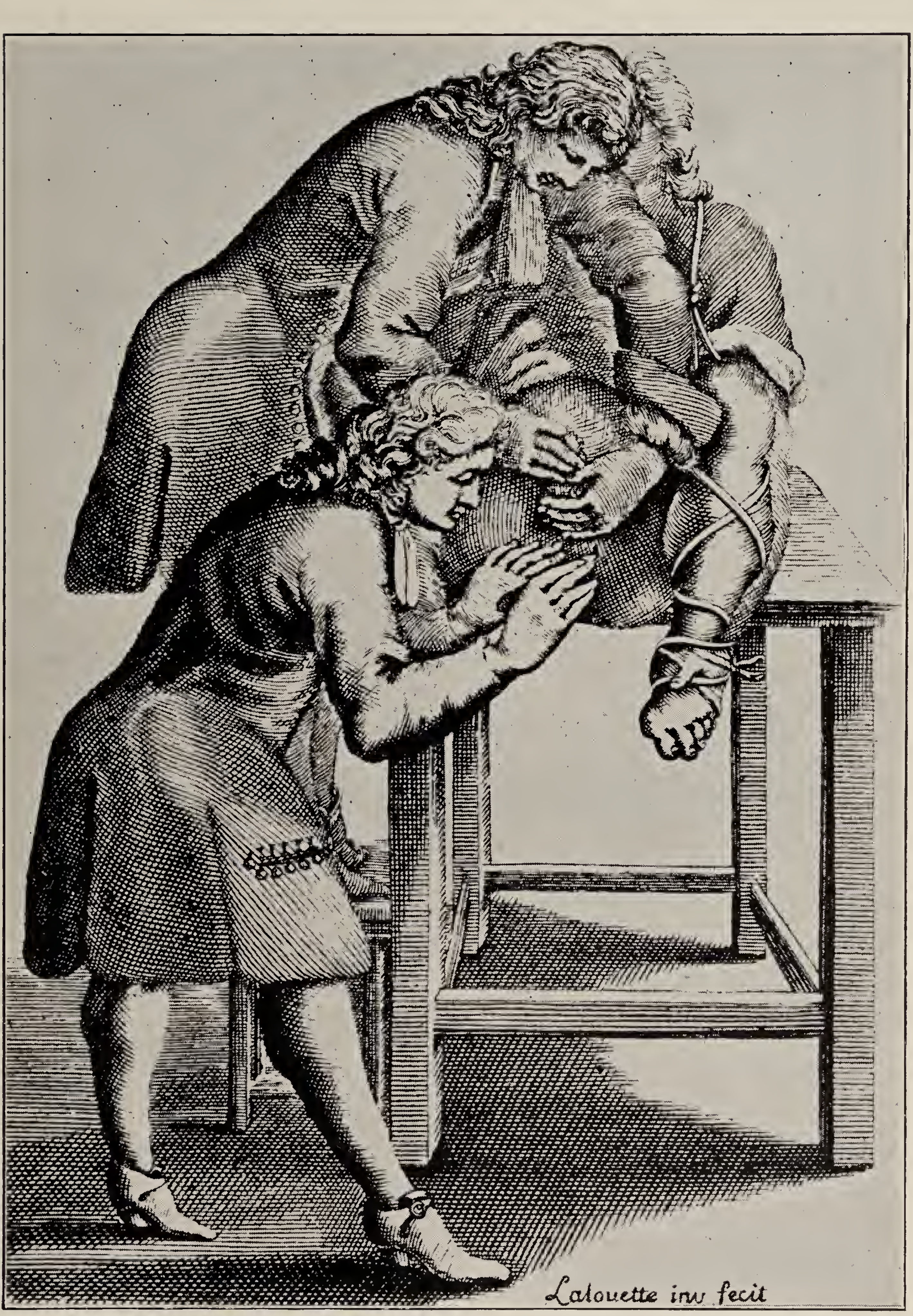

FIG. 11. The primary incision for the greater operation, as pictured by Tolet, 1682. (Desnos)

danger of irreparable injury to the neighboring organs in the genito-urinary tract. With the staff in the urethra, an incision was made into its membranous portion, and various dilators and incisors employed to enlarge the opening sufficiently to permit removal of the stone. It was because of the profusion of instruments thus brought into service that the procedure became known as the 'grand appareil.'

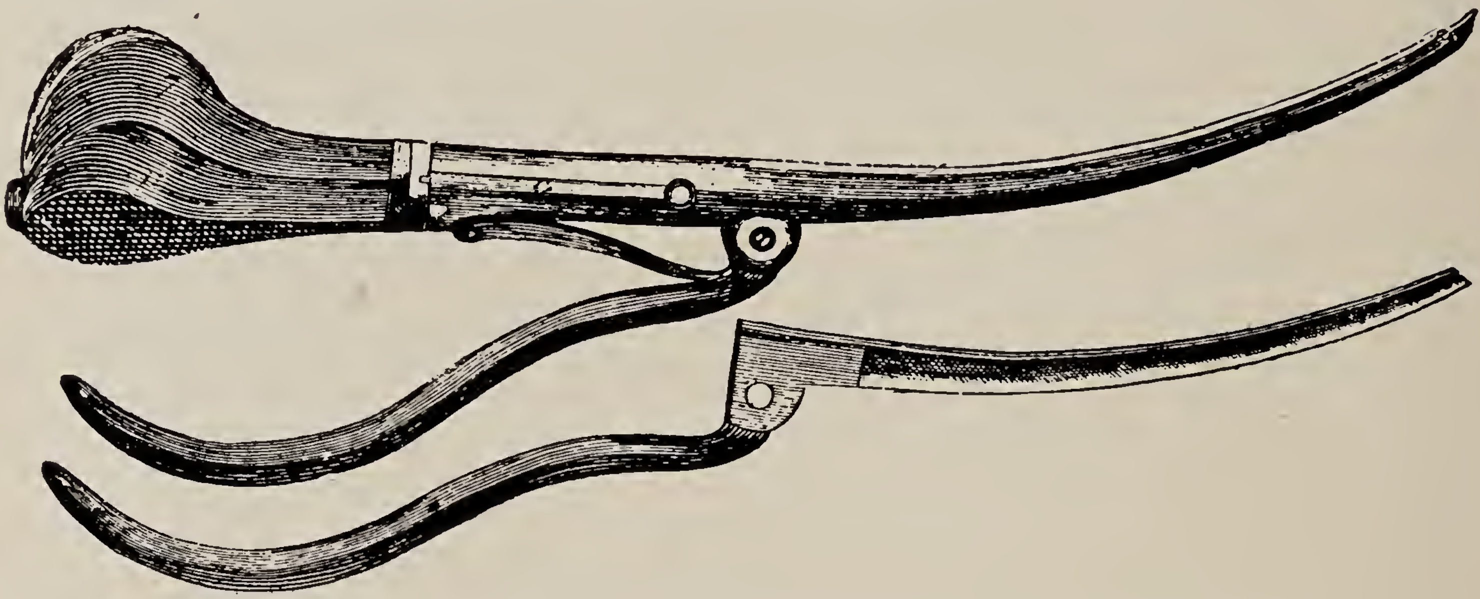

Fig. 12. Instrument in use for the lateral operation for stone; designed by Jean Baseilhac, better known as 'Frère Côme.' (Desnos)

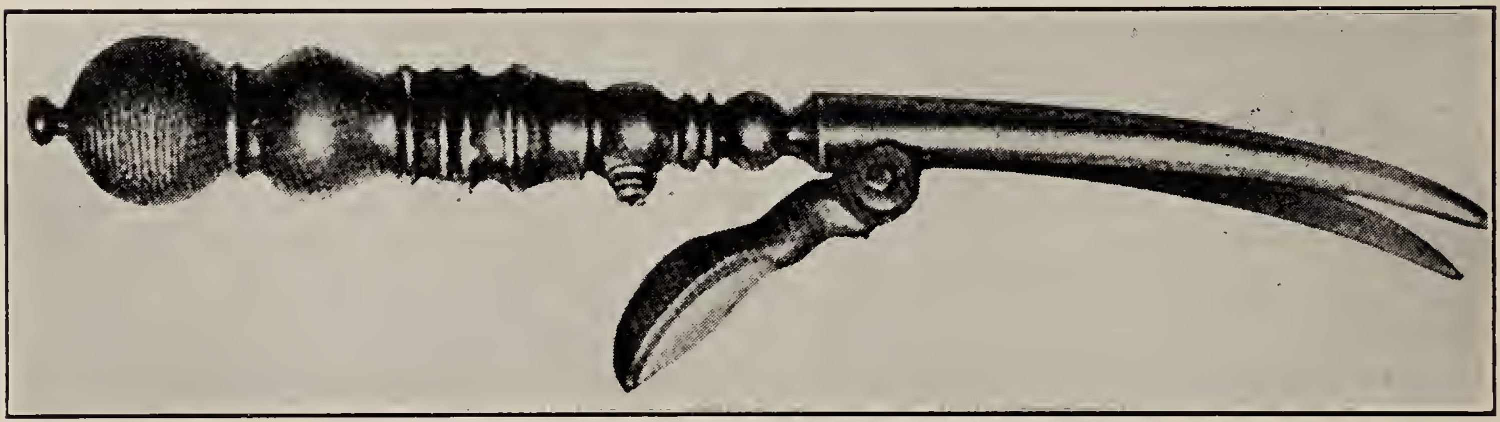

Fig. 13. Bistoury, attributed by Desnos to the end of the sixteenth century. (Desnos)

The procedure devised by John de Ramanos — to use the name by which he has been most frequently called — was employed by his pupil Marianus Sanctus, who was the author of the first written account of it. For this reason it is often termed the "Marian operation." The improvements instituted by Sanctus placed the procedure upon an established basis, and thereafter surgery of the urinary tract gradually became a legitimate part of medical practice. The work of these early lithotomists was continued during the succeeding two centuries by many able operators in both Italy and France.

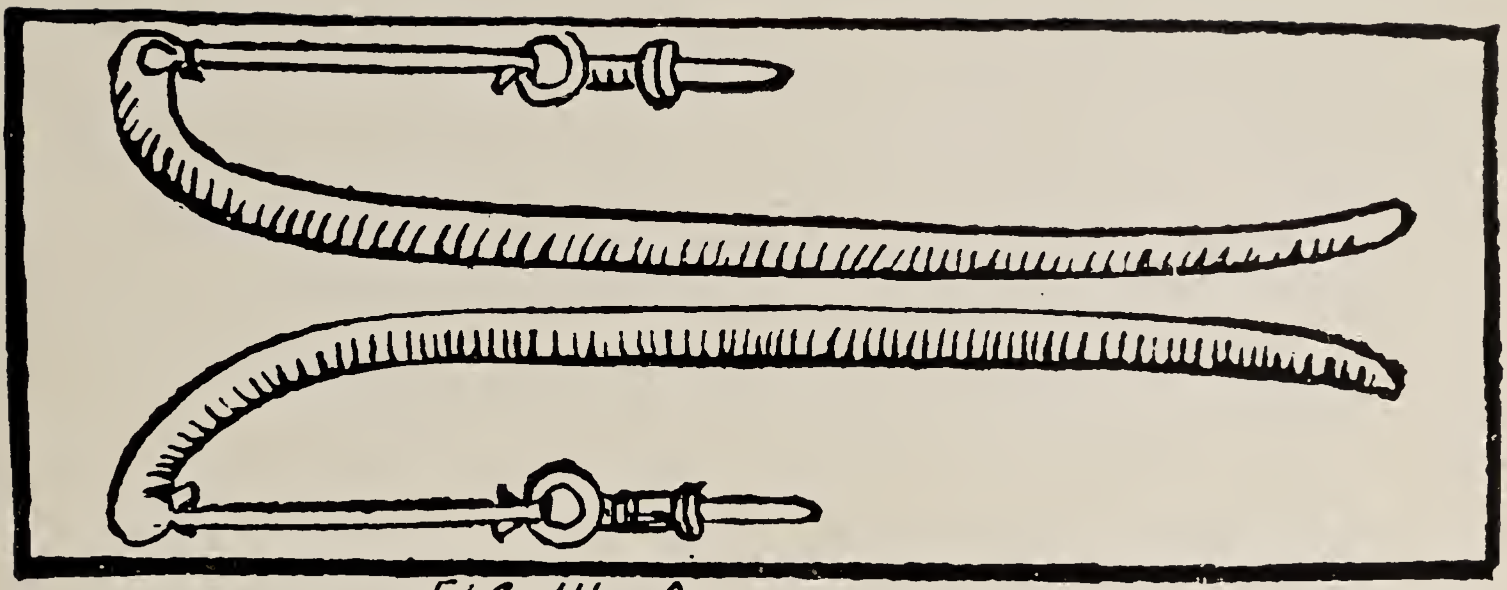

FIG. 14. A

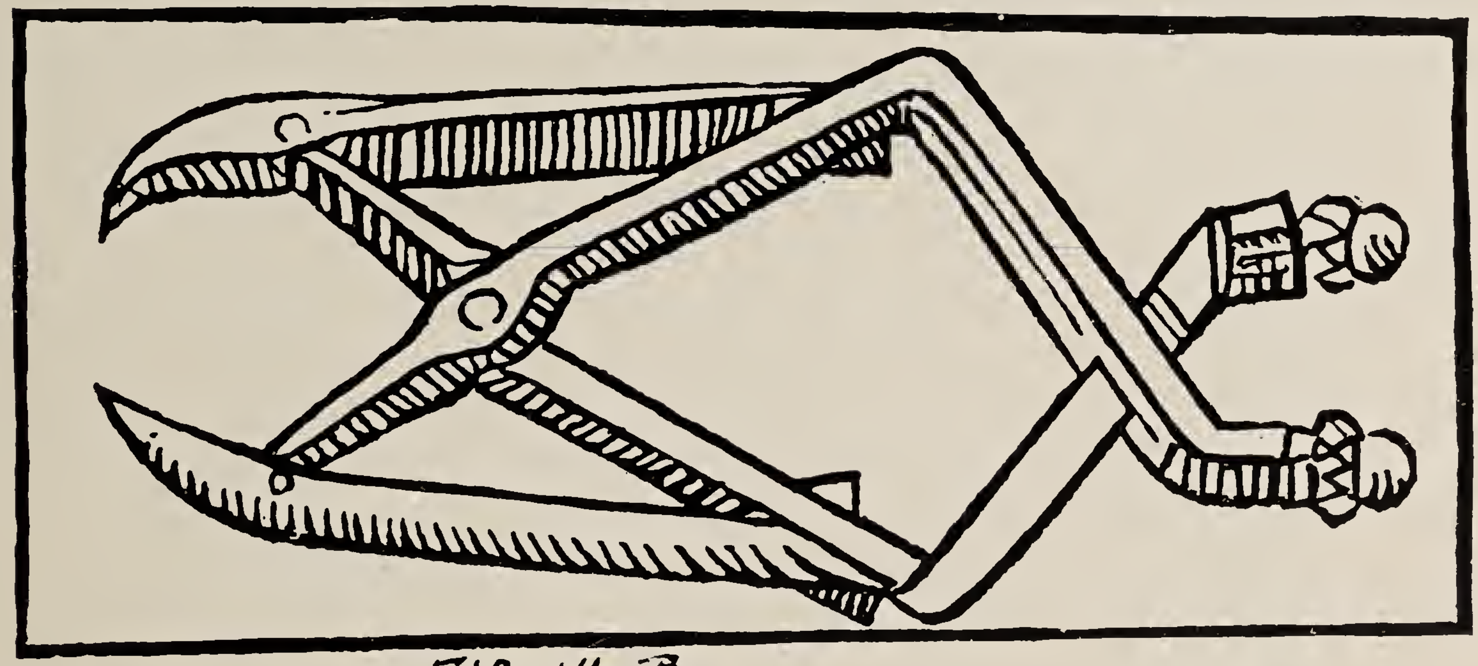

FIG. 14. B

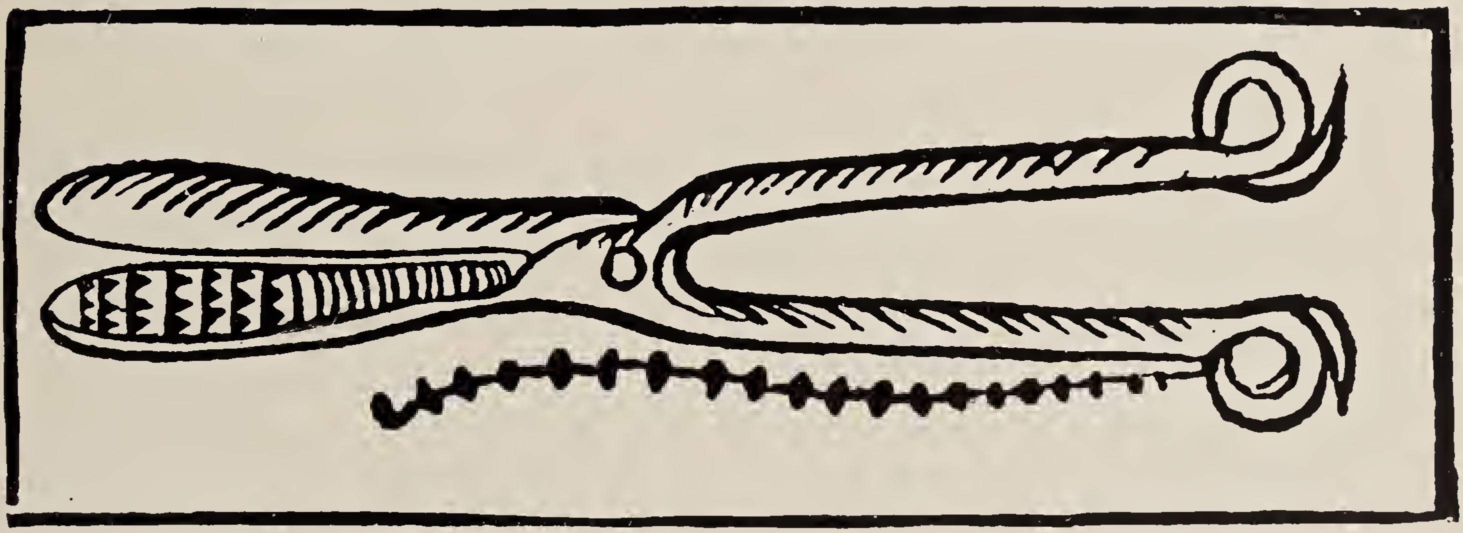

FIG. 14. C

FIG. 14. Urologic instruments of Marianus Sanctus. *A. Conductores; B. Aperiens; C. Forceps.* The *conductores* served to guide an exploring sound which the operator introduced through an incision in the perineum. The *aperiens* served to enlarge the incision, if necessary. The *forceps* was for grasping and removing the stone when the way had been opened by the *conductores*. (Desnos)

Among the best known of these were Pierre Franco, Fabrice de Hilden, and François Tolet. Franco wrote a treatise on the removal of urinary calculi, wherein he described not only his own methods but those of many of his predecessors and contemporaries as well. Tolet's *Traité de la Lithotomie*, published in 1681, was written in the vernacular instead of in the Latin usually regarded as indispensable to the dignity of medical books. This seems to have added to its popularity, for it went through no less than six editions. Fabrice de Hilden made several ingenious modifications of existing instruments. A lithotomist of great renown was Frere Jacques de Beaulieu, an ignorant Italian peasant, who is credited with having originated the lateral operation for stone. Attaching himself to a strolling *incisor* when a youth of sixteen, he traveled all over France and Italy and seems to have attained great skill in treating his master's patients. Becoming a monk, he continued his surgical travels, and eventually was admitted to practice at the Hôtel de Dieu in Paris, much to the indignation of the regular practitioners who attended there. Finally, after a great deal of public attention had been centered upon him, a series of fatalities attended his operations; whereupon fickle Fortune frowned upon him, he was discredited, and driven from Paris. His considerable contributions to the operation of lithotomy, however, remained, and the honored surgeons of the eighteenth century owed much to his pioneer work, for which he has but recently received a due meed of credit.

These eighteenth-century practitioners of the art of cutting for stone, though they attained great skill and speed — a vital factor in preanesthetic days — really made but little advance in the technique of the operation. In Italy the chief name of the period is that of Tommaso Alghisi, while in France, Claude Nicholas Le Cat, François Ledran, and Jean Baseilhac, better known by his popular name of Frere Côme, carried on the traditions of the earlier masters. An important contribution of Frere Côme was his *lithotome caché*, an instrument by means of which he obtained a better dilatation of the vesical orifice than had been afforded his predecessors. The maneuver, however, carried with it very grave danger of injury to the neighboring organs, particularly the rectum, so that incontinence or loss of sexual power often followed his interventions.

EARLY SURGERY OF THE UROGENITAL TRACT

Surgery of the kidney, the chief of the urinary organs, really had no existence prior to that October day in 1846 when the first operation was performed under ether anesthesia. But men had dreamed of doing this

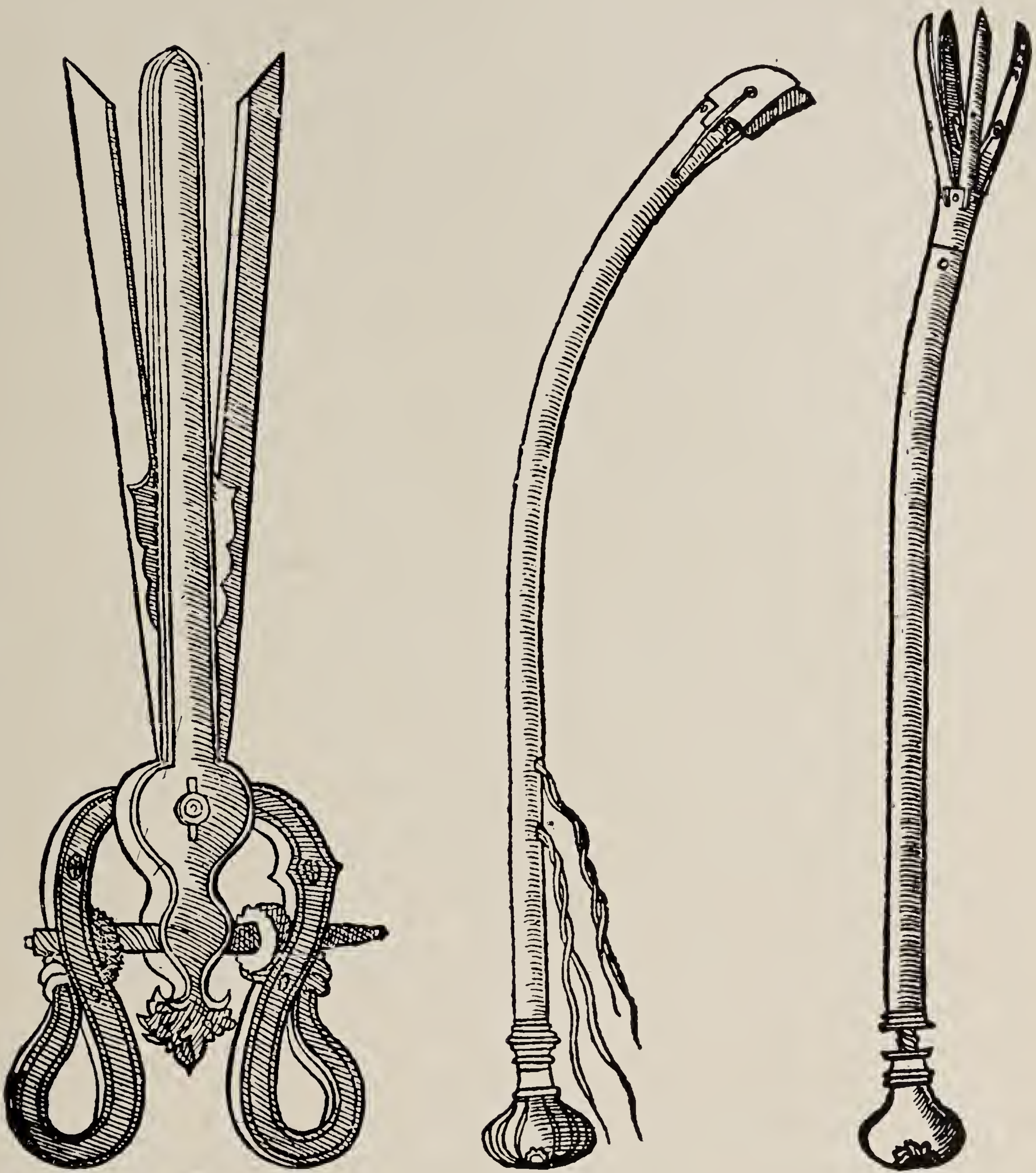

FIG. 15. Pierre Franco's instruments; *A*. Incising *Tenaculum* — or cutting forceps — probably used to cut the bladder neck. *B*. The *Fundamental,* designed to grasp the stone, was introduced closed, guided by the finger in the rectum, and pushed up to the stone. Its jaws were then opened by pulling the attached string and an attempt made to press the stone against the pubis, thus preventing it from being pushed upward. *C*. The four-fingered *Tenaculum* was designed to grasp and withdraw large stones 'the size of an egg.' (Desnos)

for many hundreds of years, and in the works of the great practitioners of the sixteenth and seventeenth centuries we now and again find references to attempts at operating upon deeper lesions than those due to vesical or urethral stone. Ambrose Paré, the greatest surgeon of the sixteenth century, gave much attention to urologic procedures, and in the textbook which he published at Paris in 1564 there were many descriptions of genito-urinary diseases and much shrewd advice upon their detection and treatment. Though the reduction of stricture by the passage of sounds was not his own idea, he seems to have been one of the first to apply common sense methods in treating this condition. Undoubtedly a pioneer in the recognition of prostatic hypertrophy as a cause of urinary retention, he must have given increasing attention to his urologic work as time passed, for to the third edition of his *Chirurgie* he added books on gonorrhea, on stone, and on urinary retention.

In this long popular textbook we also find the account of the surgical procedure done upon the "free-archer of Meudon," which, if true, would appear to be the first case of renal surgery on record. The story has several versions, but as Paré's is likely to be the most reliable, it will be accepted rather than another. It is unfortunate that this picturesque tale, like that of William Tell and the apple and so many of the pleasant legends of antiquity, has been carefully autopsied and declared apocryphal. We are told that there is no exact statement that the operation was upon the kidney — it might just as well have been upon the bladder. Indeed, it is even affirmed that the very existence of the bold, bad archer is questionable. But the fact that Paré credited the tale sufficiently to place it in his most serious work gives it a respectable credence, for we feel quite sure that he at least knew the difference between a kidney and a bladder.

Here then is Paré's version:

"I must mention in passing a certain anecdote from the chronicles of Monstrelet, concerning a free-archer of Meudon, near Paris, who was held in the Castle charged with several larcenies, on account of which he had been condemned to death. That same day it was represented to the King by a number of physicians of the City, that many citizens were suffering greatly from the stone, which caused colic and exquisite pain in the side, and that this same archer was likewise afflicted with a similar malady. The bishop of Boscage even, was in the same case. It would be of the greatest interest to observe the seat of this disease in the living subject, and therefore, what could be better than to incise the body of this criminal under sentence of death? After the disease had been so viewed, the entrails were then replaced and properly dressed by order of the King, and this was so well done, that in fifteen days the man was cured, secured remission of his sentence and a present of money. Thus," concludes the historian, " have kindly kings favored the arts and sciences." It is to be regretted that Paré was not a little more specific as to just what this exploratory operation revealed, because, as Hévin, from whom this is quoted, points out, it still remains to be proved whether or not a stone really was taken from the kidney of the iniquitous archer.

This writer, therefore, busied himself with the compilation of opinions as to the practicability of incising the kidney for the removal of stone or for any other purpose. As far back as 1581 the question had been debated by Camerarius and Francis Rousset; three years later Shenck had discussed it; in 1622 it was once more brought forward by Jean Duclédat and Cousinot, and later in the same century by Riolan and von Hilden. Shortly before Hévin himself entered the lists a number of the early French urologists — Lafitte, Borden, and Ledran — took up the subject once more, but, so far as one is able to ascertain at this remote period, all this amounted to no more than the reading of Hamlet — *words, words, words*. Of actual interventions there were apparently none whatever.

Enterprising vivisectionists as far back as 1670 had, however, made animal experiments with the intention of demonstrating that life could be maintained with a single kidney, and Zambeccarius and Roonhyzen both went on record as having succeeded in this attempt. A little later — in 1690 — Etienne Blancard in his dissertation on nephrotomia, expressed the opinion that when renal stones could not be gotten rid of in any other way, it might be possible to cut out the kidney containing them without inevitably killing the patient. He fails to mention, however, whether or not any of his patients coincided in this opinion.

In 1696 there appeared in the transactions of the Royal Society of London a case report written by Charles Bernard, relating the history of an operation performed by Dominique de Marchetti of Padua upon the English consul at Venice, Hobson by name. This gentleman, being " reduced almost to desperation " by attacks of renal colic, besought the famed Marchetti " that he would be pleased to cut the Stone out of his Kidney, being fixed in his Belief that no other Method remained capable of relieving him." The surgeon, we are told, " seemed very desirous to have declined " this proposition, " representing not only the extreme Hazard, but, as he feared, the Impracticableness of the Operation, that it was what he had never attempted, and that to proceed to it, was in effect to destroy him." The patient, however, became so importunate that the surgeon at length consented and " began with his Knife, cutting gradually upon the region of the Kidney affected, so long time the Blood disturbed and hindered his Work, so that he could not finish it at that Attempt. Wherefore, dressing up the Wound until the next Day, he then repeated and accomplished it, by cutting into the Body of the Kidney, and taking thence two or three small Stones, he dressed it up again. From this instant he was freed from the Severity of his Pain, and in a reasonable Time was able to walk about his Chamber, having been in no danger, either from Flux of Blood or Fever."

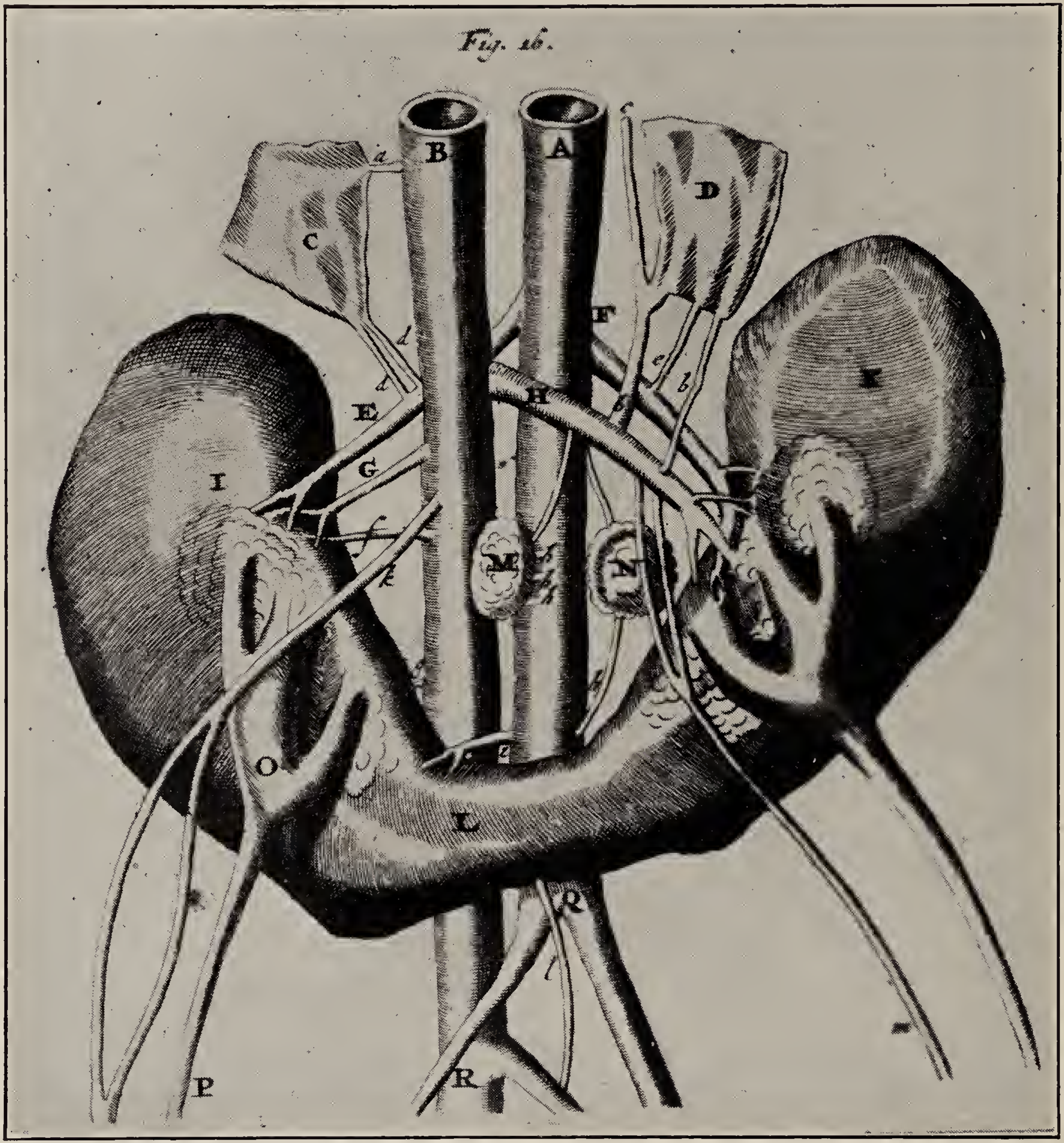

Fig. 16. Renal anomalies observed in the seventeenth century. Horseshoe kidney pictured in Bellini's *Structura et usu renum,* Amsterdam, 1665. (Library, New York Academy of Medicine.)

Advocates of two-stage operations should take notice that this medie-

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val surgeon " dressed the Wound for a considerable Time " but was never able to close the resulting fistula. After the patient had passed from under the surgeon's care, he voided another stone, and when seen by the maker of the report from which these quotations are taken, had been actively engaged at his profession for ten years, still bearing an unhealed sinus but sufiering no " Uneasiness in that Part." The author claims that this is the first record of intervention upon a kidney which presented no spontaneous fistula, but Hévin, sixty years later, was inclined to doubt that the tissues above the calculus collection were intact, as no data emanating directly from the surgeon himself is available, only the word of the subject of operation. Yet, granting this uncertainty, the procedure ranks as a major operation upon a vital organ, which had a successful outcome, quite comparable to those done since the era of aseptic surgery, and reflects honor upon Dominique de Marchetti as being the pioneer among renal surgeons.

In his *Renal and Urinary Affections*, Dickinson quotes from the *Gentleman's Magazine*, for August 1773, an account of how " Mr. Paul, a surgeon at Stroud, Gloucestershire, lately extracted from the kidneys of a woman by an incision through her back, a rough stone as large as a pigeon's egg, and made an entire cure." But without any further clinical details, this cannot be accepted, so Marchetti's achievement really stands alone until the attainment of anesthesia and asepsis made possible the interventions upon the kidney with which the present generation is familiar.

Nephrotomy continued to be resorted to in cases of renal abscess and such other conditions as marked an unmistakable path for the surgeon. In a case report presented to the Medical Society of Paris, the seventeenth Thermidor of the year 9 — or, in terms other than those of the Revolutionary calendar, August 6, 1801 — the Citizen Hippeau, late an army surgeon, cited a number of such instances. Among the names he mentioned were some famous in French medical history — Dujardin, Dionis, J. L. Petit, Gaspard, and the German Bauhin. In Hippeau's own case, he first applied a caustic plaster, apparently as a punishment to the refractory patient who refused to permit incision of the abscess. The next day he cut into the area to which the plaster had been applied, " continuing, without consulting the patient, to cut down on the kidney until the collection (of pus) was encountered." Complete cure, " with the exception of a very small fistulous opening " followed this procedure.

Nothing which could be termed an advance in renal surgery seems to have been made from the prevalence of the Revolutionary calendar until the year 1869. This year, however, is the most important in all the his-

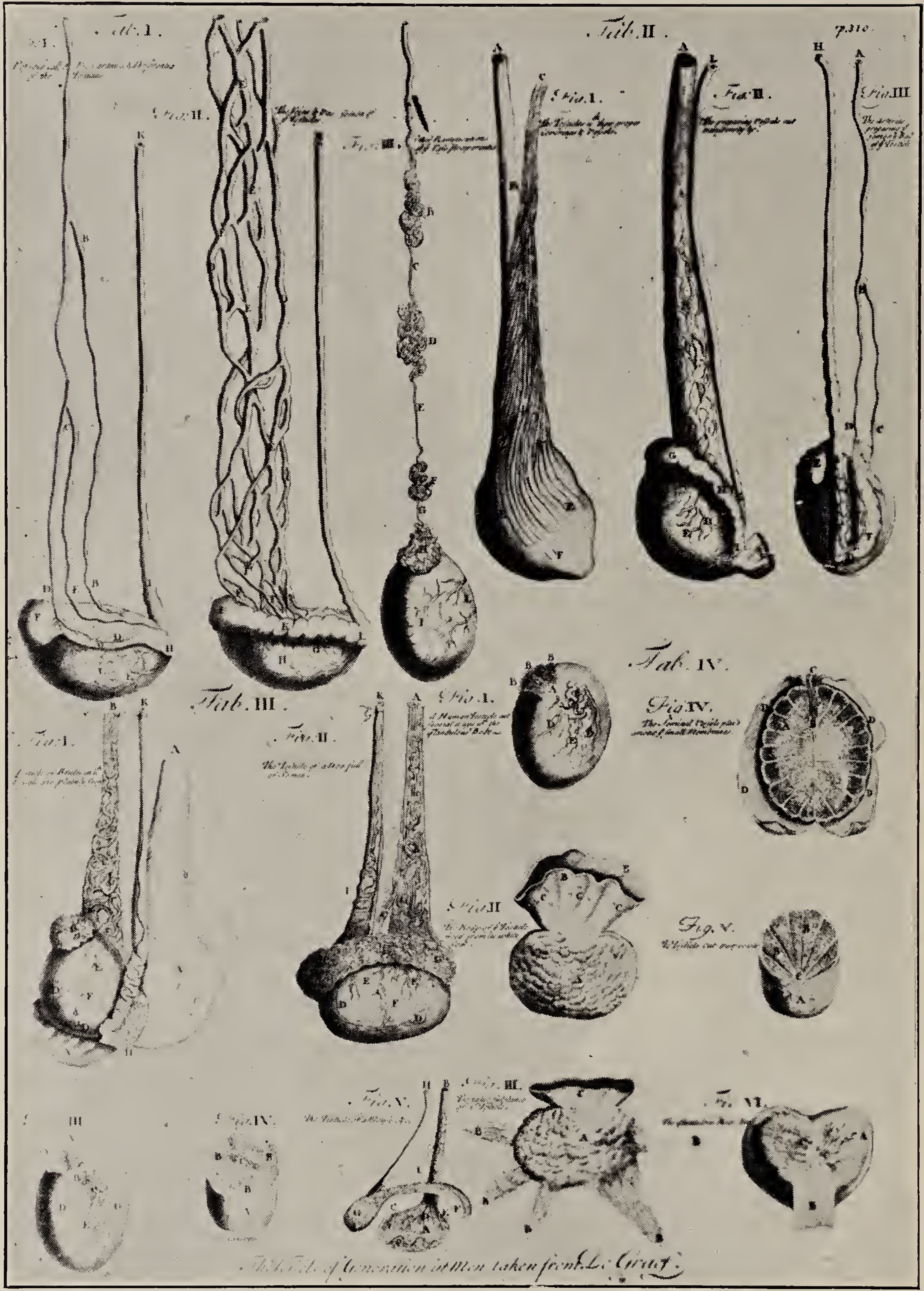

Fig. 17. An eighteenth-century conception of the male genitalia. *Bibliotheca Anatomica, Medica, Chirurgica,* etc. Vol. III, London, 1714. (Library, New York Academy of Medicine.)

tory of renal surgery, for it saw the first successful extirpation of the kidney and the epoch-making contribution of Thomas Smith of St. Bartholomew's, London, concerning the practicability of intervention upon the organ still *in situ*. Smith's proposal was as follows: " The patient being in the prone position, a longitudinal incision should be made along the outer border of the erector spinæ muscle, beginning at the lower margin of the last rib, and extending downward for four inches toward the ilium. The skin and fascia, the latissimus dorsi, the serratus posterior inferior, and a layer of the fascia transversalis being divided, the quadratus lumborum is exposed; this, with the erector spinæ, should be drawn toward the middle line with a retractor, and the body of the kidney will come fully into view; the fascia surrounding it being laid open, the finger can be passed inward, so as to touch the hilus of the kidney and feel the commencement of the ureter and pelvis. In this operation one or two lumbar intercostal arteries will be met with, and would require division and ligature; the ileo-lumbar nerve might also be cut."

Smith did not bring forward any successfully operated cases, and he recommended the procedure only for the extraction of calculi; nevertheless, his presentation seems to have given an enormous impetus to surgeons who had hitherto hesitated to cut down upon a kidney to which Nature had not yet opened up an approach. No doubt the interest in his suggestion was enhanced by the far more important work of Gustav Simon of Heidelberg, who, five months later, made the first successful removal of the kidney from the human subject. To be sure, kidneys had already been taken out of the human body, at least three such instances being on record before Simon's case, but these removals were in every case *accidental*, the surgeon supposing he had encountered something else. Simon made his diagnosis and planned his procedure in advance. Moreover, he based his reasons, not upon previous animal experimentation by others, nor even upon authentic records of subjects who had come to autopsy with but a single kidney, yet giving no evidence of having suffered inconvenience from this fact during an entire lifetime; his theory was worked out from his own experimentation upon animals, wherein he compared the results of fifteen hysterectomies with fifteen nephrectomies, and reached the conclusion that, surgically speaking, there was no more risk in performing one operation than attended the other. His observations also confirmed his belief that it was perfectly possible for one kidney to carry on the functions of both organs, even when the urinary system had undergone so severe a traumation as would be inflicted upon it by the removal of one kidney. Simon's patient was a woman of forty-six, whose left ureter had been severed during an extensive hysterectomy. In order to relieve the intolerable conditions produced by the presence of an intractable fistula in the abdominal wall, through which the urine produced by the left kidney made its escape, he decided to take out the kidney, the peculiar conditions brought about by the first operation enabling him to judge very accurately of the functional ability of the right side. The operation was most brilliantly successful, and immediately numerous surgeons in Germany and elsewhere hastened to emulate Simon's example. Unfortunately, in many cases their results did not duplicate his, and when Simon himself attempted to repeat his triumph a year and a half later, his patient died on the twenty-first post-operative day, due, it was alleged, to a digital examination made by the too complacent surgeon when he mistakenly supposed all danger of infection to be past. In the ensuing twelve years a dozen attempts were made, but all save two of the patients succumbed. This tremendous mortality so intimidated both practitioners of renal surgery and victims of renal disease, that nephrectomy seemed likely to be permanently abandoned as a procedure too dangerous to be practicable.

But in the year 1873 six recoveries after the operation were put on record. So encouraging was this that surgeons again regarded the procedure with favor, and nine years later Robert P. Harris of Philadelphia was able to collect and tabulate reports of one hundred operated cases. To be sure, forty-five of these terminated fatally, but in extenuation it must be mentioned that all the interventions were undertaken for the gravest conditions, such as carcinoma, sarcoma, calculus pyonephrosis, and tuberculosis, and many of the patients were practically moribund when the operation was suggested as a last resort.

Not the least interesting part of Harris's compilation is the geographical distribution of the cases. Exactly half were in Germany — fifty, with twenty-four recoveries and eighteen deaths; in four the final result had not then been reported. In England, there had been twenty-four cases — nine recoveries, thirteen deaths, and two unrecorded; in the United States, ten — five recoveries and five deaths; in Austria, four deaths; in Italy, two deaths and two recoveries; in Belgium and Scotland, one recovery each; in Switzerland, two deaths; in France, one recovery and one death. In Algiers and in China each, one patient had survived to let the tale be told, in the first instance the operation was by a French surgeon and in the second by an American. The first successful case in this country appears to have been that of John T. Gilmore of Mobile, Alabama, whose patient, a negress, five months advanced in pregnancy, went to full term without mishap. It seems odd that in France, where urology early received far more attention than was accorded this branch of medical practice in other countries, and where the most ardent exponents of nephrotomy had flourished, only two attempts to remove the entire kidney had been made. Both of these operations were performed by surgeons of high repute, the successful one being done by Le Dentu in April, 1875, and the one terminating fatally by Le Forte in May, 1880. It is noteworthy that Le Dentu's patient had hydronephrosis and a perinephritic abscess, and was 42 years of age. Le Forte's patient was but 23, and at autopsy showed a kidney " very slightly altered," the reason for operation being the existence of an intractable lumbar-renal fistula, resulting from what Henry Morris has designated as " a very rare form of injury, namely, a penetrating wound by a knife, which completely divided the ureter."

While it was still regarded as radical surgery to even consider removing the kidney, the more cautious were extending the indications for nephrotomy. The year 1870 saw a number of such interventions. Our own Bryant exerted an unsuccessful attempt to save a patient suffering from tuberculous pyonephrosis, and in England Gunn and Durham made bold to cut down upon kidneys believed to be harboring calculi. About the same time Lente and Barbour ventured to incise the renal tissue proper in search of stones, but, though they found none, their patients eventually outlived the mistakes of their medical attendants. In 1880 Henry Morris removed " a mulberry calculus weighing 31 grs. from the undistended and, to the naked eye, quite normal kidney of a young woman. The kidney was exposed through an oblique lumbar incision, and the stone reached and removed through the renal parenchyma." In the opinion of this operator, " this case demonstrated for the first time that a stone could be safely removed by cutting freely upon it through a thick layer of renal tissue," disproved " the supposed dangers of nephrolithotomy "; and showed " the invalidity of the objections which in all previous times had been urged against the proposal to operate upon a kidney not already converted into a mere abscess sac."

Just about this time, Hahn of Berlin modified Simon's procedure so as to apply it to the fixation of movable kidneys. He should, on this account, be credited with originating the operation now known as nephrorrhaphy or nephropexy. He made an incision beside the sacro-lumbaris muscle extending from the level of the twelfth rib as far as the iliac crest. After section of the quadratus lumborum, the renal capsule was opened at the outer border, freed for a short distance, and then carried back into the operative wound, where it was sutured and the wound kept open by means of antiseptic gauze. Morris improved upon Hahn's procedure by attaching the kidney itself to the cut edges of the transversalis fascia and the aponeurosis of the transversalis muscle. The great French surgeon, Tuffier, preferred to partially decorticate the kidney, thereafter suturing the tunica propria to the edges of the parietal wound. Modifications of Tuffier's method have been numerous, but all have the same main objective, namely, to obtain direct adhesion between the bared parenchyma and the deep tissues of the abdominal wall. "No matter whether the capsule is detached in a single piece, in small squares or triangles, or the surgeon contents himself with merely scarifying it."

Partial excision of the kidney, now generally known as heminephrectomy, was not undertaken until long after the other procedures discussed had become more or less commonplace. Bloch, in 1896, collected ten cases, to which he added one of his own. He asserts that these were all that he had been able to find in the literature up to that time. The first of these interventions was that of Czerny, done in November, 1887, for an angiosarcoma, resulting from traumatic injury. Tuffier reported three cases, two being for the removal of neoplasms and the third the cutting out of an old fistula. The second patient died on being re-operated for recurrence, but the others recovered. Kummell also operated in three cases, two for new growths and one for calculi, likewise losing one patient from recurrence of the malignancy. Bardenheuer has two cases to his credit, one for cystic tumor and one for calculi. The first patient did so badly that five days later he was obliged to take out the remainder of the kidney, after which she recovered; the second case was likewise eventually successful, although the stones which he originally intended merely to remove proved so numerous that it was necessary to eliminate practically a third of the renal tissues along with them. At the time Bloch wrote, the means of ascertaining the condition of the opposite kidney were still very limited, so that the reasons he put forward for restricting surgical activity were very pertinent. At present, functional tests and separate catheterization of the ureters, to say nothing of pyelography, have done away with most of the uncertainty which attended the renal surgeon's movements in 1896. Bloch failed to mention several cases of partial resection of the kidney which had been done in England and the United States, the most important of these being probably the incision of six tuberculous abscesses by Henry Morris in a patient whom he was exploring for calculus. The man made a good recovery, and, though the tubercular infection reappeared in the testicle, there was never any further evidence of disturbance in the renal region.

By the beginning of the twentieth century surgery of the kidney was well established, and although it has since made great strides, these have been along the line of greater exactness in diagnosis and improvements in operative technique rather than any dramatic departures from previously established practice. The master surgeons of the present still employ the

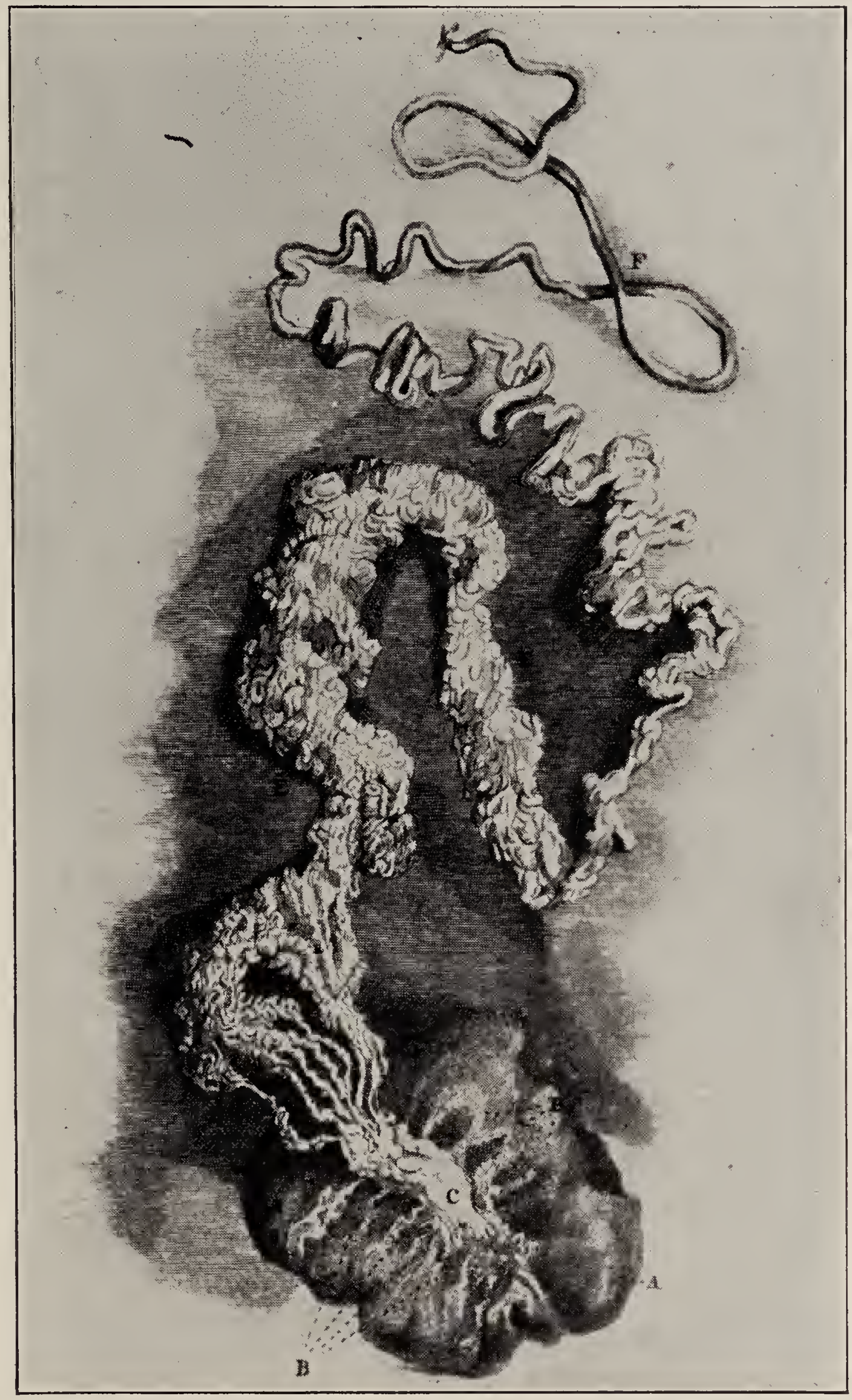

Fig. 18. 'The epididymis and testicles injected with quicksilver and dissected.' From *The Anatomy of the Human Body*, by Charles Bell — discoverer of Bell's muscles — London, 1804. (Library, New York Academy of Medicine.)

main principles laid down by the founders of urinary-tract surgery, and though we may well congratulate ourselves upon the achievements of the present day, we should, nevertheless, be ever mindful of the debt we owe to those who ventured where no man had ever before dared to set his hand.

UROLOGY IN THE EARLY NINETEENTH CENTURY

Retracing our steps to the opening of the nineteenth century, we find that other phases of urogenital work received a great impetus at that time, this being especially notable in the field of renal diseases which are classed as *medical* rather than *surgical.* In 1827 there was published in England the observations of Richard Bright upon nephritis, with his epoch-making distinction between cardiac and renal ‘ dropsy,’ one of the greatest single contributions to medical knowledge ever made. The medical side of urinary disease henceforth received a portion of the interest and study which its importance warrants. It was not until twenty years later, however, when the discovery of anesthesia made possible interventions hitherto deemed beyond human ability, that equal attention came to be paid to urologic surgery.

It was in France that the first great urologic surgeons displayed their preëminence, giving especial attention to the designing of instruments for use upon the genito-urinary tract. Souberbiele, who devoted himself especially to lithotomy, is said to have employed the suprapubic method in more than 1200 cases. Lithotrity was introduced by Civiale, who successfully performed it upon a human subject in 1824. A three-pronged instrument for seizing and perforating a vesical calculus had already been perfected by Leroy d’Etiolles. Still another great French urologist was Heurteloup, who devoted the greater part of his professional life to the study of lithotripsy and to the designing and perfecting of instruments for the furtherance of his chosen specialty. While the term *urologist* was not yet a part of any language, and the men just mentioned were recognized only as general surgeons, it is but just to number them as among the pioneer specialists in urogenital work. Other Frenchmen, distinguished for their ingenuity in devising more suitable tools, were Reynaud, credited with being the originator of medio-lateral lithotomy; Vidal de Cassis, whose procedure was known as the “ quadrilateral ”; and Civiale, noted in several other lines, whose “ medio-bilateral ” operation was introduced by Sir Henry Thompson into England, and became the basis for some procedures still in use.

The French tradition has been carried on by the adopted sons of that nation, for the greatest urologists of the immediate past were natives of French colonies, chief among them being Felix Guyon and Joaquin Albarran, whose textbooks and procedures are still standard throughout

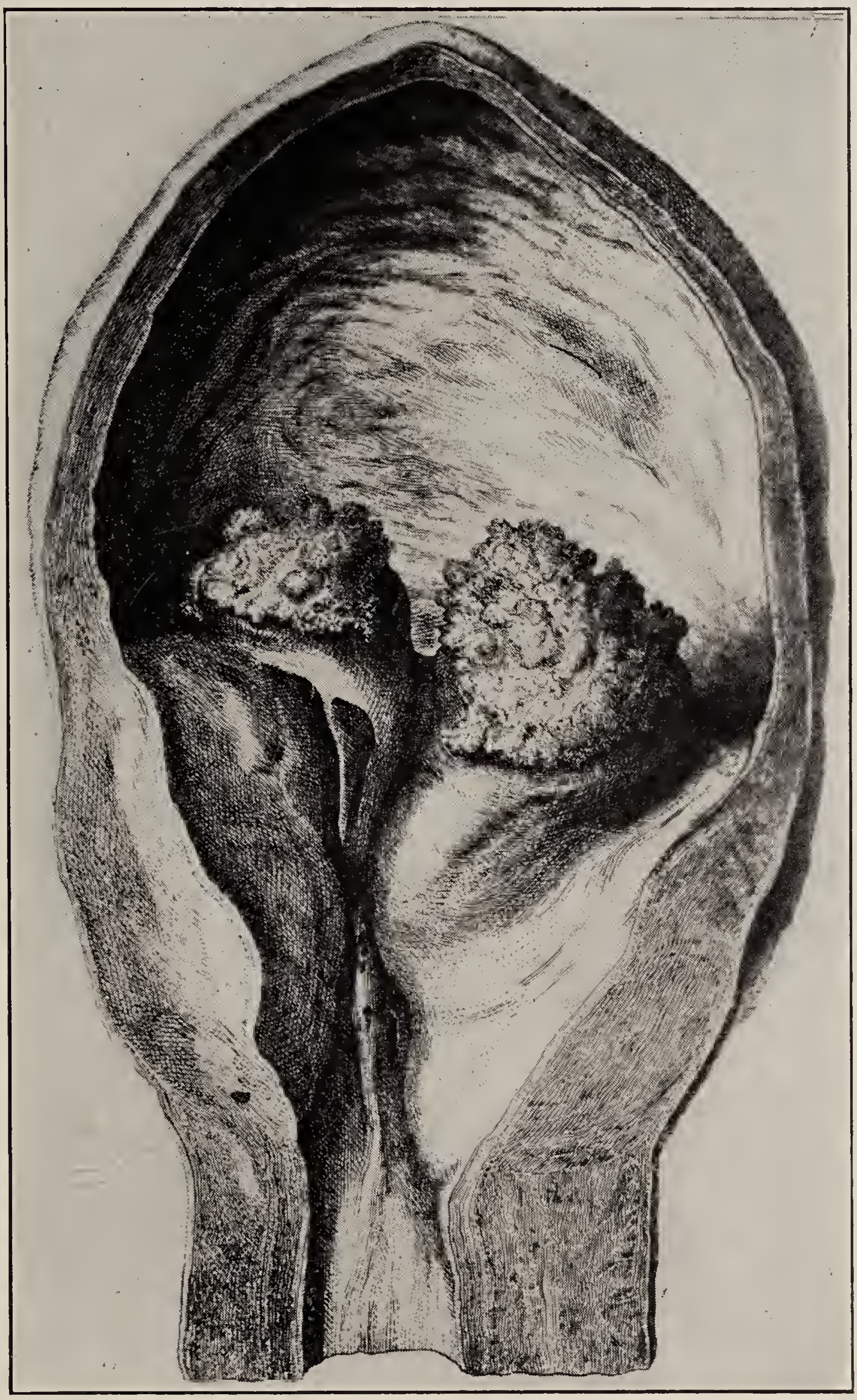

FIG. 19. Cancer of the prostate. Plate XII — p. 277 — in Everard Home's *Practical observations on the treatment of diseases of the prostate.* London, 1811. (Library, New York Academy of Medicine.)

the world. Another Frenchman, a surgeon but not primarily a urologist, wrote the first textbook on surgical diseases of the prostate. This was August Socin, and his work, published in 1875, marks the beginning of modern study of an important phase of genito-urinary work which had received but little attention before his day.

Urology shared with other branches of surgery in the great extension which the application of Teutonic thoroughness and deep learning brought about, when Germany and Austria became medical centers of world importance. Dietl, whose name has come down to us in connection with movable kidney, was a prominent operator of this period. Gustav Simon, as we have already seen, in 1869 performed the first successful previously planned nephrectomy. Casper and Israel applied to urology the results of the stupendous labors of Teutonic pathologists and biologists, chemists, and physicists. Finally, in 1877, Max Nitze gave to the world the first practical cystoscope, the instrument upon which the practice of urology, as we now know it, may be said to have been founded.

SURGERY OF THE PROSTATE

As far back as Hippocrates' time, it had been noticed that elderly men frequently suffered from some obstruction to urination which seemed to be definitely connected with the advance of age. Early in the eighteenth century surgeons had been able to palpate, in the living, changes in the conformation of the parts adjacent to the outlet of the bladder, and had made postmortem examinations which exposed the pathology induced by urinary obstruction. In 1812 Charles Bell described to the Medical and Chirurgical Society of London " a set of muscles attached to the orifices of the ureters and seated in the bladder which seem not to have been observed by former anatomists." He believed that the function of these muscles was " to assist in the contraction of the bladder and at the same time to close and support the mouths of the ureters." He also thought that the action of these muscles accounted for the frequently observed enlargement of the third lobe of the prostate when the other parts of this gland suffered no hypertrophy.

It is, of course, now fully recognized that Bell's conception of the function of the trigone was erroneous. Modern embryologic investigations of this particular section of the vesical wall show that it is placed there, not to inhibit regurgitation of the bladder content into the ureters, but to act upon the process involved in opening the urethral orifice so that the accumulated bladder content may be evacuated through the urethra. It has been demonstrated that the circular fibers incorporated in the main bladder wall, on reaching a point opposite the vesical neck, change their direction so as to pass obliquely downward until they join the course of the external longitudinal muscles, and are carried around the urethra so as to form a sort of arch before the vesical outlet. This knowledge does away with the older conception of an "internal vesical sphincter" regarded as a muscle separate and distinct.

Occasionally, cases have come under observation where obstruction to urination existed with hypertrophy of the trigone but no enlargement of the prostate. Investigation showed that the hypertrophy of Bell's muscles was the cause, not the result, of the urinary obstruction. But in most cases a prostatic enlargement is the origin of the trouble. It has been pointed out by Deaver and others (in modern times) that hyperplasia of Albarran's tubules is most prone to be the cause of the median bar obstruction. Occasionally, instead of the bar there will be a rounded nodule which is separated from the lateral lobes of the prostate gland by deep clefts, one on either side. The lobule itself is grossly trilobular, the clefts separating the individual lobules being caused by the pressure exerted by Bell's muscles, bundles of which pass over it from the trigone above to the urethral floor below. In general, increase in the size of the subcervical glands of Albarran will be found responsible for hypertrophy of Bell's muscles and the rest of the musculature of the trigonal region.

This explanation serves to show why hypertrophy of the prostate gland itself and enlargement of the tissues adjacent to it were not recognized as distinct pathological entities until comparatively recent times. The history of prostatic surgery, therefore, must perforce include that for urinary retention in general, even though this may not have been due directly to the prostate. No extensive interventions in this region were possible until after the discovery of anesthesia and a widespread recognition of the teachings of Pasteur and Lister. But long before this, attempts had been made to force a passage for the dammed-back urine. John Hunter, the English surgeon and pathologist whom Hugh Young has termed the founder of scientific surgery, was one of those who thus tried to bring relief to the sufferers from prostatic obstruction, but the operation proved altogether too dangerous, and very few physicians, or patients, could be found to undertake the attendant risks. Death followed Billroth's only attempt to thus open a way to the bladder, but certain French operators were more successful, in that they employed gradual dilatation by means of compression rather than violent tunneling through completely occluded passages. A somewhat similar procedure was successful in the hands of Philip Physick, the American surgeon.

Because intraurethral manipulations were fraught with so much pain and danger, surgeons naturally turned to the ways of approach employed by the lithotomists of earlier periods. Indeed, from some of the accounts which have come down from remote times, it seems very probable that these very men undertook to obviate the effects of prostatic or median lobe hypertrophy years before the existence of such pathologic entities was even recognized. Sir William Fergusson is definitely known to have combined perineal prostatectomy with lithotomy long before the introduction of anesthesia. By the commencement of the nineteenth century a good deal of practical knowledge of the prostate gland and its pathology was in possession of the medical profession. Beside the treatise of Socin, of which mention has been made earlier, several others had given the subject extensive consideration, in particular Sir Everard Home, whose textbook on prostatic diseases was standard for many years.

The first operation for the relief of prostatic hypertrophy seems to have been done by George James Guthrie, an English army surgeon, who served with the British troops in our War of 1812 and was with the forces of Wellington when they met Napoleon at Waterloo. He published a book entitled *Anatomy and Diseases of the Urinary and Sexual Organs* about the time that the final exile to St. Helena put an end to the Napoleonic Wars and permitted Guthrie to undertake private practice. In this volume we read of his arrival at the following conclusion: " An elastic structure exists at the neck of the bladder and may be diseased without necessary connection with the prostate gland." A little further on he says, " The prostate gland may be diseased without any necessary connection with the elastic structure." This appears to be the first recognition of the condition most commonly known as median bar obstruction.

No particular attention was paid to Guthrie's observation, so when, a dozen or so years later, the French surgeon Mercier promulgated a similar idea, it was hailed as something quite original. Indeed, Guthrie's connection with median bar obstruction would hardly have been revived at all had it not been cited by Civiale, another French urologist, in his reply to Mercier's accusation that Civiale's writings on the subject of median bar obstruction had been plagiarized from Mercier's own. Even then, Civiale merely designated him as " some English surgeon " without mentioning his name. Guthrie had divided " the bar at the neck of the bladder " by means of a catheter which carried a concealed blade, and Civiale also made use of an intraurethral incising instrument. Mercier improved and made original designs, but there seems to be little doubt that Civiale's contribution was made prior to Mercier's, despite that choleric individual's furious outcry to the contrary.

The controversy, for which Mercier was largely responsible, was vigorously waged for a number of years, each party to the dispute claiming priority in the investigation of the nature of median bar hypertrophy causing obstruction at the vesical outlet, as well as originality in the design of an instrument for its surgical relief. But Mercier, after the fashion of the Pharisees, succeeded by means of his " much speaking " in getting the entire credit for this important contribution to urology. Even to-day the condition concerned is often referred to as *Mercier's bar.* In 1850 the French *Academie des Sciences* awarded Mercier a prize of 1,500 francs, crediting him among other achievements with having " perfected the construction of instruments, easy of handling, by the aid of which one either incises or excises the valve (i. e. the obstruction) in a manner to produce a more prompt and certain cure."

If Mercier really did add anything to what Guthrie had already said and done, it was not of sufficient interest to the practitioners of his time to keep the subject actively before them. We hear little more of it in medical literature until the perfection of the cystoscope immeasurably increased the possibilities of urologic examination. And even then, so much more attention was paid to hypertrophy of the prostate gland itself, as well as to the pathology higher up in the urinary tract which its existence engendered, that the symptoms of median bar hypertrophy were confused or entirely overlooked. The *prostatisme sans prostate* of Guyon and the French school of the last decade of the nineteenth century was a vague conception, blaming vesical obstruction, in the absence of prostatic lobe enlargement, upon muscular changes in the bladder wall induced by arterio-sclerosis. This was, in effect, a return to the teachings of Charles Bell. Finally, in 1905, Charles H. Chetwood collected all the designations for the condition which were in use at that time — and found a surprisingly large number — and suggested that in their place all should employ a single phrase: *contracture of the neck of the bladder.*

While these pathological differentiations were gradually emerging, many who were engaged in urologic practice had striven to find a way of eliminating the enlarged prostate, an idea which Home had entertained as the faintest possibility of the far-distant future. It is reported of Amuset that in 1827 he cut off with scissors a rounded nodule which was preventing the outflow of urine at the bladder neck, and some of the implements designed by d'Etoilles, Mercier, and others were employed with a view to cutting away the enlarged lobes. But the first definite proposal to remove the entire prostate seems to have come from von Dittel, a Viennese surgeon. It was about the year 1880 when he began his investigations, but not for five years longer did he have the hardihood to actually attempt excision of the gland. His efforts were not crowned with success, but he persisted; yet it apparently never occurred to him to abandon the old perineal route followed by lithotomists from the earliest times.

It remained for the Scotchman, McGill, to envisage a new method of reaching the hypertrophied gland. He made use of the suprapubic lithotomy incision perfected by Sir Henry Thompson, the foremost British urologist of his day, and through this attacked the prostatic enlargement where it had encroached upon the floor of the bladder. The idea of the suprapubic cystotomy quickly appealed to surgeons concerned with this very common urologic lesion. In fact, others besides McGill had conceived the idea independently — Belfield of Chicago being perhaps the best-known example. Belfield, however, usually employed a combination of the perineal and suprapubic approach. In the United States, Gouley of New York was for many years a most ardent advocate of the perineal method. Finally, just at the beginning of the twentieth century, Freyer of London devised and practiced a method of enucleation by the suprapubic route which combined the good features of the previous attempts while eliminating many of the risks to which the procedure heretofore had always exposed the patient. Eugene Fuller in this country and Reginald Harrison in England had previously done much to advance the operation of prostatectomy, and to promote a more intelligent understanding of urogenital pathology in general, but Freyer's procedure had over all the foregoing methods the advantage of operating *away from* Santorini's plexus, instead of *toward* it. Hemorrhage, always the greatest dread of the prostatectomist, was thus very greatly lessened. The complete perineal prostatic operation, as we are accustomed to think of it at present, is the conception of Zuckerkandl, and finds its best exemplification here in the work of Hugh Hampton Young.

MAX NITZE AND HIS FOLLOWERS

Before advancing any further in the recent history of prostatic surgery we must consider the greatest single factor in modern urologic practice, the instrument which has made modern urologic diagnosis possible. This is the cystoscope invented by Max Nitze in 1876.

This instrument had a number of forerunners, and it is evident that medical men had for ages dreamed of being able to look into the natural cavities of the body by some employment of reflected light. An apparatus having this end in view had been made and demonstrated before the Medical Faculty of Vienna as early as 1806 by Bozzini, a resident of

Frankfurt. The Medical Faculty were not impressed by its possibilities and the idea lay dormant for a number of years longer. In 1824 John Fisher of Boston made a similar design, while Segales of Strasburg produced much the same thing on the European continent. These attempts were, however, entirely abortive, and no notice was taken of the subject until 1853 when Desmoreaux employed the same ideas, but put them to such practical use that he has been generally accorded the title of "Father of Endoscopy." Desormeaux's system of tubes and mirrors served excellently to illumine the urethra, but it was not until the introduction of the platinum loop, which enabled the operator to carry the source of illumination inside the passage itself, that any satisfactory view of the bladder was possible.

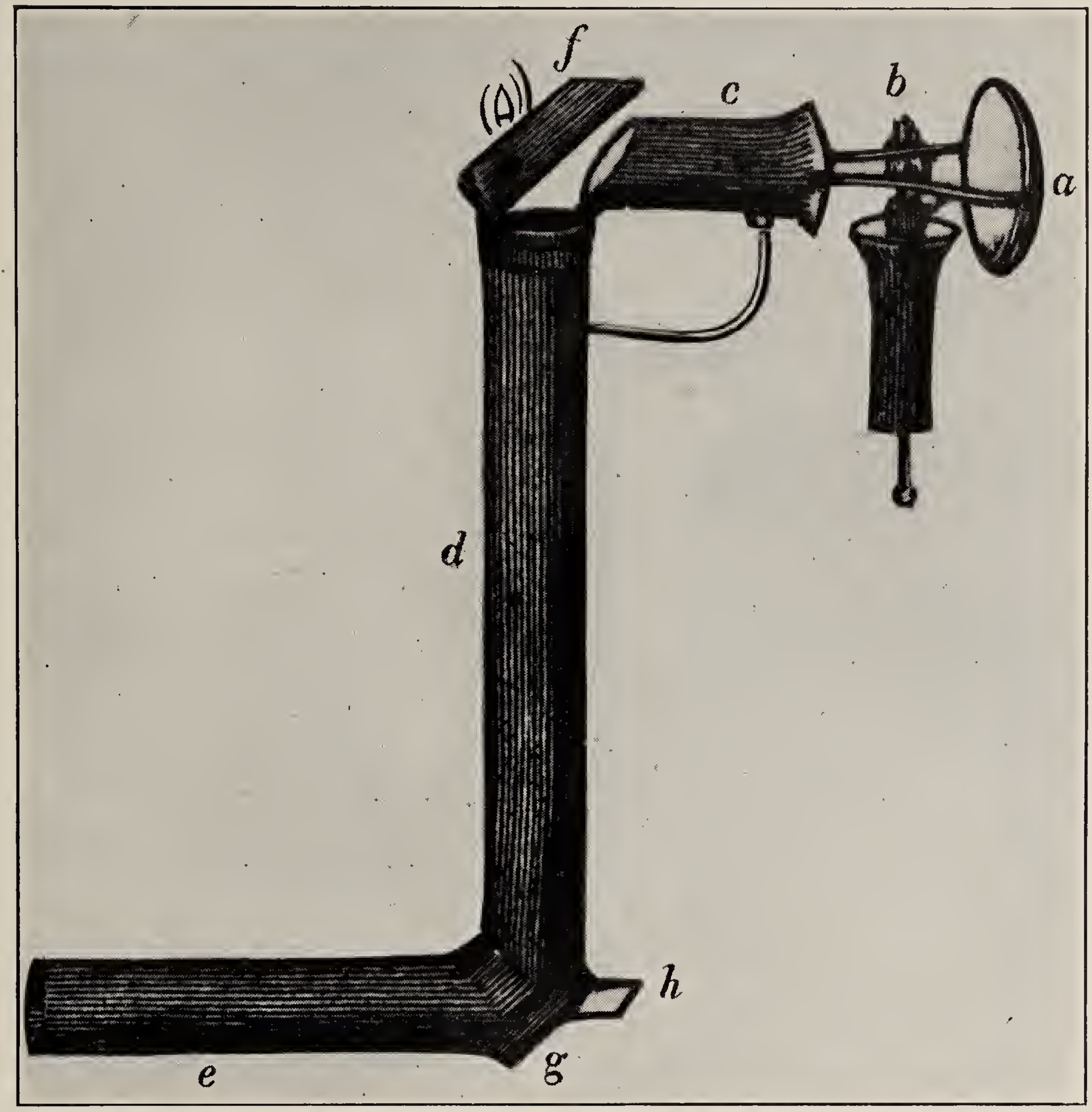

FIG. 20. Fisher's endoscope, pictured in *The Philadelphia Medical Repository*, 1827. (Library, New York Academy of Medicine.)

The idea of the platinum loop originated with a Breslau dentist named Julius Bruck. In order to view the cavities in his patients' molars, he used a loop of platinum wire, kept at a white heat by means of a galvanic current. He suggested its possibilities for exploration of the bladder and rectum, but, although some Vienna physician attempted to put it to this use, the experiment was not successful, and Bruck's idea was very soon forgotten. When Nitze finally succeeded in producing a practical cystoscope, he employed the same principles in the use of which Bruck had preceded him by almost ten years. It is, therefore, to Bruck, rather than to Nitze that the credit for originating this truly remarkable device should be accorded. A water cylinder, supplied with a continuous stream of cool water from a cistern suspended overhead had kept Bruck's loop cool, and a storage battery had maintained the wire at the point of incandescence.

Nitze now took Bruck's plan and adapted it to an instrument shaped to enter the urethra. The mechanical difficulties encountered were enormous, and it was not until Nitze obtained the help of the Viennese instrument-maker, Joseph Leiter, that anything practical was evolved. Leiter finally succeeded in simplifying the water-cooling apparatus and increasing the brilliancy of the light, but compared with the cystoscopes in use to-day this first instrument was unbelievably cumbrous and awkward. Unless the physician who attempted to use it was an excellent mechanic as well, he soon desisted from the attempt. It is hardly to be wondered at that urologists generally did not concern themselves with it until after it was equipped with an incandescent electric light, which, oddly enough, was not until 1887, although these lights had been used for house and street illumination since 1880.

THE ELECTRO-CAUTERY AGE

We may now return to the subject of prostatic surgery, for with the acquisition of the cystoscope the modern surgeon had a third route of approach at his disposal. He could return to the path followed by the lithotomists of old without " cutting " — from the outside at least — yet his work could be done under full vision.

Almost coincident with Nitze's first presentation an Italian surgeon, Bottini, had originated a method of removing prostatic hypertrophy or median bar obstruction, as the case might be, by using the actual cautery. Seventeen years later Albert Freudenberg of Berlin revived Bottini's technique, which had been practically forgotten, and applied it to the cystoscope. Freudenberg called his contrivance a *cystoscopic prostatic* *incisor.* In our own country, Charles H. Chetwood had quite independently devised a somewhat similar implement, designed especially for median bar excision. He did not, however, use a cystoscopic feature, but applied the cautery through the urethrotomy incision. Chetwood's procedure was later described by Alexander Randall as "practically a Bottini-Freudenberg operation performed after better diagnosis and under better control."

Various operators both here and abroad rapidly made improvements in the early models. Conspicuous among these were the productions of Wossidlo and of Goldschmidt. Wossidlo's tube had a slight turn to the convex aspect and carried a small tube attached to the side through which air might be forced by attaching a bulb. Goldschmidt's model used the principle of Nitze's lens system, employing the cystoscopic optic and convex lenses of smaller diameter than the object searched for, thus widening the field of vision. With this device it now became possible to view with ease the interior of the bladder and the conditions at the vesical neck. Also, the differentiation between true prostatic hypertrophy and median lobe enlargement was susceptible of more exact interpretation.

The electro-cautery has been combined with cystoscopic features in a variety of ways during the past ten years. The chief reason for its employment is, of course, the control of hemorrhage. Its use for cutting is a later, but perfectly logical development of the original hemostatic feature. The scope of this brief historical résumé is too limited to permit a detailed account of the development of vesical neck resection and the improvement of instruments designed for use in this operation. It must suffice to say that at present intraurethral methods of removing obstructions at the vesical neck are occupying the attention of urologists both in the United States and abroad to such an extent as to dwarf interest in most other surgical procedures. It seems probable that in the near future open operation will be employed much less often, and there is even a possibility that with improved technique it may be practically superseded.

RADIOLOGIC UROLOGY

When Konrad Roentgen gave to the world his remarkable discovery of the x-ray, its possibilities as a diagnostic medium at once became apparent. In no department of medicine has roentgenology proved to be of more signal service than in urologic work. Early in July, 1896, less than a year after Roentgen made his announcement, a case of renal calculus was detected and afterwards successfully operated upon by James

Adams, a Glasgow surgeon. The man who suggested the x-ray work was James McIntyre, and he was likewise successful in obtaining a series of very good photographs of the pelvic region. McIntyre thus emerges as the pioneer in roentgenology of the urinary tract.

In March of the following year (1897) James Swain of Bristol, England, perceived a distinct shadow in the region of the left kidney, and notwithstanding the fact that the negatives were " thin," so that a good print could not be made from them, an incision into the parenchyma of the x-rayed kidney came upon the stone exactly where the radiologist had located it. Henry Morris and Laurie and Leon, also English surgeons, soon after successfully demonstrated the presence of renal calculi, and our own Robert Abbe, pioneer in radium as well as x-ray application to therapeutics, was able to collect 27 cases wherein a diagnosis of renal calculi demonstrated by radiography had been confirmed at operation. Soon the English Fenwick succeeded in obtaining a fair representation, *in thin people and children*, of the kidney, and in some cases, unimpeachable evidence of renal calculus. He also fluoroscoped a kidney delivered through the operative incision, as a means of detecting small, deep-lying stones, being apparently the first one to employ this at present very common way of avoiding unnecessary mutilation during pyelotomy.

At the opening of the present century, Charles F. Leonard, who became one of the foremost American authorities on roentgenology, developed a technique by which he positively detected renal calculus 100 times out of 136, with but one recognized error. Later, he reported on 300 more examinations of suspected kidney and ureteral calculus, in only five of which no stone was found at operation.

The detection of calculus was not the only way in which the x-rays found urological application. A revolver bullet was located by E. Adenot in the left kidney of a seventeen-year-old boy, and, thanks to the x-ray indication, this surgeon was able to remove it without permanent damage to the involved organ. Ledham-Green and Hall-Edwards, physiologists, distended the bladder with bismuth suspension and introduced a slender metal bougie into the urethra, thus being able to visualize the function of the bladder more exactly than had ever before been done. In some of their observations they used collargol instead of bismuth, this having been suggested to them by reports of the work of Voelcker and von Lichtenberg in Germany, two urologists who were the real discoverers of pyelography.

The idea which these two developed was not wholly new, for, as far back as 1897, Tuffier of Paris, in a contribution to the *Traité de Chirurgie* of Duplay and Reclus, had advocated radioscopy of the ureter after the passage of a metal catheter. He was able to show a fairly close reproduction of a skiagram made on the living subject, with a sound equipped with *un mandrin métallique souple* in position in the ureter. Schmidt and Kolischer advocated a similar procedure in 1901, using a urethral catheter in which a wire had been inserted. Four years later Fenwick suggested the employment of a ureteral bougie, the walls of which had been previously impregnated with a suitable metal. It was apparently Klose who was first inspired to use an injection of bismuth suspension through the ureteral catheter, thus rendering kidney pelvis and ureter opaque to the penetrating rays. Klose was unable to make his idea practical, but his attempt nevertheless paved the way for the success of later investigators.

Voelcker and von Lichtenberg recommended their method especially for the diagnosis of hydronephrosis, and believed it might also prove useful in the detection of tumors of the kidney or anomalies in the structure of the urinary tract, although they had not applied it for any such purposes. No extended report by other investigators who had used their method appeared for several years, but finally, in 1908, Albarran, in conjunction with Paul Ertabischoff, published his experiences, giving eight detailed cases. It was soon after suggested by von Lichtenberg that the dilated ureters might be outlined by filling the bladder with collargol solution. The same idea was put forward here by J. B. Clarke, who advised putting the patient in the Trendelenberg position, as this would promote gravitation of the fluid into the ureters. Much work along diagnostic lines was also done by other American urologists, notably William F. Braasch and Young and Waters. In England the method found a sponsor in J. W. Thomson-Walker, and its clinical possibilities were illustrated and discussed by Kidd and Alfred Johnson.

But, though urologic workers fully appreciated the great possibilities of urinary tract radiography, one serious drawback prevented a widespread use of the method. All the opaque media known were very toxic, and a number of fatalities and serious accidents made conservative urologists extremely cautious in making use of such a dangerous means of diagnosis. But little was known also of the amount of pressure which could be safely employed in forcing the medium into the renal pelvis. Numerous investigators struggled for years to overcome these disadvantages. In March, 1918, Donald F. Cameron proposed that a 25 per cent. solution of sodium or potassium iodid be substituted for the silver solutions previously employed. In October of the same year, sodium bromide was brought forward for the same purpose by E. H. Weld. Cameron later decided that the hypertonicity of a 25 per cent. solution of sodium bromide might be too great, and substituted a 13.5 per cent. solution with equally satisfactory production of opacity. The osmotic pressure of such a solution is lower than that of any of the media used before, and but little above that of concentrated urine. It is isotonic with 8.2 per cent. sodium bromide. As soon as these media came into general use the employment of pyelography became widespread, with resultant improvement in all forms of urinary tract examination and diagnosis.

Nevertheless, the performance of pyelography, or any of the other x-ray examinations of the urogenital tract made opaque to the rays by filling it with some suitable medium, remained a trying, and often rather hazardous procedure, at least from the patient's standpoint. In 1921 Rosenstein in Germany and Carrelli and Sordella in South America independently suggested the injection of the perirenal tissues with gas. The injection of air and gas had been previously made use of in cystography. In 1904 Kellar had distended with air a bladder in which he was thus able to demonstrate the presence of diverticulum. A good many mechanical difficulties attend this procedure, and it never gained any lasting popularity in this country. Skilful clinicians continued to work with sodium bromide or iodid, gradually improving the technique, until comparative safety and satisfaction attended all such diagnostic undertakings.

Intravenous urography. In 1929 the whole procedure of roentgenographic diagnosis in urology was revolutionized by the introduction of intravenous pyelography. The idea had been fermenting in the minds of many workers for a number of years previously, Rosenstein in 1924 having attempted to introduce the opaque medium into the kidney secretion in connection with his pneumoperitoneal methods. Animal experiments had been made both here and abroad, but it remained for an American student, working with von Lichtenberg in Berlin, to crystallize the findings of many investigators along different lines of endeavor into a practical method of intravenous introduction of the medium, instead of injecting it by pressure directly into the urinary tract.

This man was Moses Swick of New York, and the compound with which he finally succeeded was supplied to him by Professors Binz and Räth, who were connected with the clinic of Professor Lichtwitz at Altona, Germany, where Swick first pursued his studies. The substance, which was proved clinically applicable, was a member of the Selectan group, having high iodine content, great solubility, and very general clinical tolerance. First introduced as *Uroselectan*, the compound has now received the official designation of *Iopax* from the Committee on Pharmacy of the American Medical Association.

So short a time has elapsed since its introduction that one cannot as yet write any history of the use of intravenous urography. It bids fair to supersede largely, if not entirely, the older methods, but a great many disadvantages must first be overcome before it can be universally adopted. In the hands of wise and skilful clinicians it is applicable in many instances where the use of the direct injection method is wholly out of the question. Already it has been useful in filling many gaps in diagnostic findings which previously confused and hindered urologic workers. The introduction of another substance for intravenous urography — Skiodan — an iodo-methane-sulphonate of sodium, which was presented in April, 1930 — may prove of assistance in doing away with some of the drawbacks which now encumber the intravenous method. The whole subject has been well evaluated by Young and Waters in the most recent edition of their *Urological Roentgenology*:

> Intravenous pyelographic methods do not compare in completeness with the information which is furnished by ureteral catheterization, functional tests, chemical and bacteriological studies of separated urines, and retrograde pyeloureterograms. In order to do thorough complete urological examinations, ureteral catheterization and the studies which can be carried out by means of it are of paramount importance. On the other hand these drugs which can be used intravenously to obtain urograms have a very distinct place, and often furnish valuable information. They are undoubtedly an extremely important addition to the armamentarium of urology.

OTHER ADVANCES IN DIAGNOSTIC MEASURES AND UROLOGICAL TECHNIQUE

In tracing the progress of urology along special lines some very important factors in the rise and advance of this specialty have received no attention. Chemistry and biology have given much aid. The various tests of urinary function, which reached their culmination with the production of Geraghty and Rowntree's phenolsulphonephthalein excretion procedure, have been ably seconded by the developments in roentgenographic technique just enumerated.

Radiation therapy. Not only has x-ray served to make diagnostic procedure infinitely more exact; it has also proved therapeutically useful. Roentgen's discovery was shortly followed by that of the Curies — radium — which gave to medicine an invaluable aid in the struggle against malignant disease. Inasmuch as the urogenital tract is more subject to cancerous invasion than any other part of the body, the employment of radiation has fallen very largely into the hands of urologists and gynecologists, and at present both radium and x-ray are widely applied in every urologic clinic.

Other physical agents. Diathermy, likewise, has taken a most useful place, particularly in the treatment of bladder tumors. Ultra-violet light now leads as a measure applicable to cases of urogenital-tract tuberculosis, either subsequent to operation or as a substitute in inoperable — particularly bilateral — cases. Although all of these physical agents were first made available by Europeans, it has been by the urologists of the North American continent that the greatest advance in the means of employing them has been brought about. In the case of radium, especially, this has largely been due to the great impoverishment of Europe since the World War. Only in the United States have time and money been available for the experimental work that must of necessity precede the general use of a new modality. Nevertheless, American urologists have every reason to be proud of their share in the advancement of this branch of medical work.

Regional anesthesia. Though several mentions have been made of the tremendous effect the discovery of ether anesthesia had upon urologic surgery, no history of urology could make any claim to completeness which did not take account of regional anesthesia and the part it has played in the more recent developments in surgery of the genito-urinary tract. Indeed, so closely has the advance of this form of anesthesia been related to the progress in diagnosis and surgical technique witnessed during the last decade in all divisions of urologic work that the story of the one becomes of necessity the story of the other.

Local employment of cocaine. Though the anesthetic properties of the cola plant were recognized by the early Peruvians and communicated to Europeans soon after they occupied this continent, it was not until 1860 that the drug which we now know as cocaine was isolated from it. Almost twenty-five years then elapsed before the Bohemian physician, Koller, hit upon the idea of applying it to living tissues in order to render them insensitive to pain. Once the possibilities of this technique were offered to public notice, its appeal to those engaged in urologic work was assured. Within three months of Koller's original publication, a 4 per cent. solution of cocaine had been injected into the bladder for the performance of litholapaxy by two operators — one in England and the other in New York — working quite independently, while the French genito-urinary surgeon, Reclus, immediately began to employ it in his work, finding it particularly useful in operations upon the urethra.

The real originator of the regional method, however, was Corning, who published, in 1885, an article entitled *Spinal anesthesia and local medication of the cord.* In this, he related how he had injected cocaine between the spinous processes of the lower dorsal vertebræ, which had produced anesthesia of the legs and genitalia to such a degree that a sound passed through the urethra was not felt at all by the patient. But the drug proved so dangerous, and its effects were so variable upon different subjects, that little progress was made for a number of years after Corning first showed the way. When Quincke demonstrated in 1891 that lumbar puncture was feasible and not over-dangerous, the thoughts of urologists, for whom general anesthesia was often difficult or impossible, turned once more to the possibility of restricting anesthesia directly to the field of operation. But it was not until the unremitting labors of chemists and physicists had given us less toxic modifications of cocaine that regional anesthesia was able to make any real headway.

The introduction of non-toxic agents. After the World War preparations of cocaine which were less likely to have deleterious or even fatal effects became widely available, and since the introduction of stovaine (1903), procain or novocaine (1904), and, more recently, butyn and tutocaine — to name the best known of these derivatives — regional anesthesia has come into its own.

Spinal anesthesia, after undergoing many fluctuations in popular favor, has now attained a relative standardization in the method of Pitkin, introduced three years ago. Paravertebral anesthesia had its first application to urologic work in 1911, when Läwen of Leipzig blocked the nerves from the ninth thoracic to the third lumbar and removed a stone from the kidney of an individual so old and debilitated by cardio-vascular disease as to be inoperable under a general anesthetic. This demonstrated the extreme value of this form of analgesia for operations upon impaired kidneys in aged or greatly enfeebled patients, as such individuals can never be subjected to general narcosis. The method did not take the fancy of the medical profession in this country, and very few of the foreign writings upon the subject were circulated here or translated into English. The World War beginning not long after, the whole subject remained more or less in abeyance so far as peace-time urology was concerned, but with the return of the medical men from overseas service to private practice, a remarkable revival of interest in regional anesthesia was manifested. In 1920, Gaston Labat, who ranks as one of the foremost advocates of regional anesthesia of the present time, came to this country to reside, and, under his guidance, local infiltration, nerve-blocking, and other methods of inducing insensitization to pain have seen wide acceptance in urologic as in all other forms of surgery. The translation of the textbooks written by Braun has also been influential in extending the employment of all forms of regional as opposed to general anesthesia in the United States.

Sacral anesthesia. For prostatic work, particularly, sacral anesthesia has proved most advantageous. This is known under various designations, indicating slight differences in technique. *Parasacral anesthesia* is the infiltration of the sacral nerves on the anterior surface of the sacrum. *Caudal block* means injection into the sacral canal by passing the needle through the sacral hiatus. It is sometimes known as *epidural anesthesia. Trans-sacral anesthesia* is the injection of the individual sacral nerves through the posterior sacral foramina. *Sacral block* is the combination of caudal block with trans-sacral anesthesia. Labat's combination of caudal block with trans-sacral anesthesia has proved one of the useful ways of administering anesthetics now available for urologic work.

AMERICAN CONTRIBUTIONS TO UROLOGY

The rise of urology as a specialty can hardly be assigned to any particular country, yet it presents certain developments, notably the perfection of instruments during the last quarter century, which are so peculiarly American that it seems fitting to make mention of them in a separate section.

In the preceding pages reference has been made to most of the epoch-making additions to the practice of urology contributed by inhabitants of the United States. We have spoken of Philip Physick, whose name always seems so singularly appropriate, who was among the first to attempt instrumental dilatation of the urinary passages occluded by prostatetic hypertrophy. We have mentioned the distinguished part that American surgeons — Belfield, Chetwood, Fuller — played in the early history of prostatectomy as well as of later accomplishments in improving the technique of the same procedure.

In the history of urologic instrumentation a long list of American names has been compiled — John Fisher, in 1824, being at the head. Edwin Beer's technique of vesical fulguration introduced an entirely new viewpoint in regard to the treatment and prognosis of vesical neoplasms. Corning's contribution to regional anesthesia has resulted in the saving of literally thousands of lives of urological patients who thereby were enabled to undergo operations when their physical condition was such that the use of a general anesthetic was absolutely prohibited.

In the section on roentgenologic practice we have named several who have given the world a better understanding and a more practical technique of roentgenologic diagnosis than the Europeans, who originated the methods, were of themselves able to supply. The story of urologic roentgenography is almost wholly a story of American endeavor, at least in so far as its later chapters are concerned.

Yet there still remain many names worthy of notice which I have not even mentioned, and we have as well a heavy debt left undischarged to the men who have worked with American urologists, embodying their ideas in tangible form, who, though not members of the medical profession, are none the less deserving of honor for their invaluable contributions to the specialty of urology.

The first American urologists. The first Americans whose names are peculiarly connected with urologic surgery, and who achieved fame outside the confines of their own birthplace, were Samuel D. Gross and Henry Jacob Bigelow. Gross's textbook on genito-urinary diseases went through numerous editions and held its position of authority until very recent times. Its author enjoyed the distinction of being the first surgeon with the temerity to open the abdomen in an attempt to repair a ruptured bladder. Bigelow studied in France, and, as professor of surgery in the Harvard Medical School, did much to extend the best influences of the French school of urology among the young medical graduates in the United States. Bigelow's lithotrite, an instrument for the removal of vesical calculus, revolutionized the treatment of urinary stone, and is still in use, only slightly modified. Both of these men began their life work before Morton demonstrated the practicality of ether anesthesia, or Lister and Pasteur showed the world how to avoid wound infection. They lived to see American surgeons honored wherever the English language is spoken. They also saw that portion of the practice of surgery in which they had excelled lifted from the disrepute in which it had once languished to the plane of an art worthy of the most eminent practitioners. And all this was largely through their individual efforts.

Yet it was not until Nitze gave eyes to the American urologist that the peculiar genius of our people for instrumental advancement was demonstrated in the practice of cystoscopy. The very atmosphere of this continent seems almost to give an impetus to advancement along this particular line. Natives of foreign countries, expatriated to our own, have been of greater service to their chosen specialty after coming in contact with the ideals and customs peculiar to the work of medical men in the United States. Nitze's cystoscope found little favor with us until it was modified by Tilden Brown of New York, and the multifarious uses to which members of the American medical profession have since adapted it are witness to the extraordinary genius of our people for subjugating mechanical arts to the uses of science and the benefit of mankind.

In the history of prostatectomy the application of cystoscopy in diagnosis made by Americans is an outstanding feature. And until the introduction of intravenous pyelography, the application of roentgenography to urologic investigation was only possible by the aid of the cystoscope as it had been modified and perfected by American ingenuity. It was an American, Valentine of New York, who was the first to place an electric light in the endourethroscope, and the most notable modifications since Nitze's original device, bearing the names of American urologists, indicate how much the world of medicine in general owes to these Americans.

It remains, however, to speak of the workers who have actually forged these tools, to the use of which American urologists undoubtedly owe the preëminent position they occupy to-day. In the summer of 1929, Albert E. MacKay, describing himself as " a pioneer urologist," told the American Urological Association, meeting in his home state of Oregon, something of the history of urology as a specialty in the Northwest.

" Early in the century a Tilden Brown direct new cystoscope came to hand, and then to me a new field of endeavor seemed to unfold itself in urology. . . . With startling rapidity then came the discoveries and modifications of Bransford Lewis, Buerger, McCarthy and others more modern, but it seems to me American urologists owe a large meed of praise to that artist-mechanic, Reinhold Wappler, who made possible the rapid adaptation of the ideas presented."

The present author has selected this tribute to Mr. Wappler from a vast number to be found elsewhere, because, in his opinion, the phrase ' artist-mechanic ' so fitly describes the qualities signalizing Mr. Wappler's characteristic genius. It is not enough to be able to reduce to lines and symbols upon a sheet of paper the ofttimes hazy conceptions of a urologist who hopes to attain greater perfection in diagnosis and operative intervention by means of a new instrument. This instrument, moreover, exemplifies features hitherto unthought of and is, quite probably, mechanically impossible of execution. Wappler, indeed, does all this and more. But, over and above it, he has a mind so constituted as to be able to vault the obstacles before which the surgeon has long hesitated uncertainly. By an almost miraculous appreciation of the possibilities of instrumentation, as related to surgery and insertion into the various cavities of the living body, he puts into concrete form the crude imaginings of the usually impractical physician or scientist.

The debt which everyone connected with urology — whether he be doctor, patient, or mere interested onlooker — owes to this wonderful craftsman and most delightful gentleman, is infinitely greater than has been generally realized even by those best acquainted with the facts.

The last quarter of the nineteenth century was the halcyon period of a group of general surgeons who attained such skill and distinction in the special field of urology that they are always thought of as being particularly devoted to that branch of medical art. Among the chief names are those of Edward L. Keyes, Sr. of New York, Eugene Fuller, and Ramon Guiteras, a Cuban by birth but an American in his professional ideals and connections. One of the best short treatises on the history of urology is the address which Guiteras, as President of the American Urological Association, gave to that body when they met at Saratoga in 1902. Keyes is perhaps best known to the medical world at large for his authorship of what has longest held its place as the standard textbook of our specialty. His name is not associated so much with spectacular operative technique, nor the designing of new instruments; rather, he excelled in the practice of the best traditions of our art — as a keen diagnostician, a skilful operator, and an untiring and trustworthy physician, in the finest sense of a word all too often misused.

Of this same period was Fessenden N. Otis, whose name is known wherever urology is practiced as a specialty because of his studies and elaboration of the technique of operation on the strictured urethra. Another American of this time whose name is internationally known was W. H. S. Gouley (already mentioned as a prostatectomist), whose work on strictures was soon extended to include the treatment of prostatic hypertrophy and resection of the vesical neck. To him belongs the honor of being the first American surgeon to undertake operative intervention upon the prostate.

European surgeons inaugurated the operative treatment of urinary obstruction due to enlargement of the prostate or to contracture of the bladder neck, but, as we have already seen, the work was very early taken up (1886) by Belfield of Chicago, who performed the first suprapubic prostatectomy to be done upon this continent, more than a year before McGill made public his work along the same lines. Soon after, another American, F. S. Watson of Boston, published a monograph in which were collected the records, as far as they were available, of most of the prostatectomies performed up to that time, and advocated his own special method, which was really a combination of the suprapubic and perineal approaches. It is notable that at the outset he used a galvanocautery instrument incorporating some of the features of that designed by Bottini a dozen or more years before, but that later he discarded cauterization and returned to his early method. Watson's book called attention to what the American surgeon was doing toward the advancement of the treatment of prostatic hypertrophy, and it was not many years after its publication before they became acknowledged masters in this particular branch of urologic work.

Among the most brilliant achievements of American urology is the renal function test of Rowntree and Geraghty. Yet, it is but one of the results of chemical and pharmaceutical experimentation which has made American work notable during the past twenty years. In addition, many contributions to the embryology and anatomy of the urogenital system have been made by American scientists. Before the present century began Eugene Fuller had published the findings of his studies on the vasa deferentia and seminal vesicles. In 1912 Lowsley made his epoch-making research on the embryology of the prostate gland, these studies being so complete and extensive that later writers can find nothing to add to them, so that he remains the leading authority after the lapse of twenty years. Ernest M. Watson, Alexander Randall, and Milley B. Wesson have more recently given us valuable information on the surgical pathology of the genito-urinary tract, the work done on the vesical neck in particular being a notable addition to urologic knowledge.

Roentgenology. Much of the advance in urologic roentgenology is a manifestation of the genius of American laborers in this field. The substitution of a harmless opaque medium — sodium iodid — for the toxic media first employed in pyelography, was the conception of Donald Cameron. This revolutionized urologic diagnosis, for visualization of the urinary tract now became safe and comparatively easy in skilled hands, so that the entire practice of the specialty was immeasurably benefited.

In conjunction with this, American roentgenologists and the urologists who worked with them devised cystoscopic roentgen-ray tables, whereby the taking of pyelograms became a more scientifically accurate process. The adaptation of the Bucky diaphragm, with grids running transversely instead of longitudinally as in foreign-made apparatus, has permitted taking stereoscopic films of the entire urogenital system, thus widely extending the uses and diagnostic possibilities of urological roentgenology.

CONCLUSION

The extent of that branch of medical science which we call *urology* is at present so vast that nothing more than a glance at the activities of our own day has been possible. To do the past five years full justice would require a volume by itself. With the many diagnostic and clinical aids now at his command, the practitioner in this specialty can arrive at his conclusions with more scientific exactness than any other medical worker. Indeed, the history of urology now in the process of being made will be a record of continuous progress, of still greater refinements in technique, and of more strictly scientific investigation of each recurring problem. Though but a few years ago the medical world questioned whether urology had any right to be regarded as a specialty at all, its place is now accorded without question. There is every reason to hope that the urologist's achievements in the future will equal, if they do not outstrip, those he has made in the past, and will be such that the entire medical world will be able to point to them with pride.

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CYSTOSCOPY AND URETHROSCOPY

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CYSTOSCOPY AND URETHROSCOPY

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CYSTOSCOPY

Cystoscopy is the art of examining the bladder and kidneys by means of a specially devised instrument called the cystoscope.

A cystoscope consists of a metal tube or sheath with a lamp for illumination at its distal end and a telescope or lens system, with an eye piece at its proximal end, which is adapted to slip through the sheath, fitting snugly so as to prevent any leakage from the bladder.

Cystoscopes are of two kinds, direct and indirect. In the direct, the view obtained is perpendicular to the axis of the cystoscope, and in the indirect the view is deflected 90 degrees. The direct is more suitable for some conditions; the indirect for others. The author personally prefers the indirect for routine use.

Cystoscopes are also of three varieties, depending upon their use: 1. *Examining*, for observation only; 2. *Catheterizing*, for observation and catheterization of the ureters; and, 3. *Operating*, for performing intracystic operations, e.g., removal of stones, specimens of tissue for microscopical examination and destruction of papillomata, et cetera, by fulguration.

In recent years, however, cystoscopes have been devised that combine all varieties in one instrument.

Many men have had a part in the development of the cystoscope: notably, Bozzini, John Fisher, Albarran, Nitze, F. Tilden Brown, Elsner, Brenner, Caspar, Bransford Lewis, Otis, Buerger, McCarthy and Braasch. All of the above models have been superseded in America by the Brown-Buerger, McCarthy, Young and Bransford Lewis instruments, though men trained at the Mayo Clinic under Braasch are quite partial to his instrument. It is rather a noteworthy fact, however, that although at the Clinic the Braasch instrument is used for catheterization, when careful inspection and examination are done the Buerger or McCarthy scope is used. On the continent Buerger says the Albarran cystoscope is favored.

History of the cystoscope. According to Lowsley and Kirwin, Bozzini of Frankfurt, in 1806, made use of a " lichleiter," but it was considered impractical by the medical faculty in Vienna. In 1824 John Fisher, of Boston, Mass., designed an instrument for viewing the bladder. Segales of Strassburg, in 1826, made a similar instrument but neither made any impression on the medical profession. In 1853 Desormeaux embodied the original principles of John Fisher and made a practical instrument which was improved by Cruise of Berlin. In 1867 Julius Bruck, a dentist of Breslau, devised an instrument for dental illumination in which the source of the light was a platinum loop heated by the galvanic battery. He also designed a cystoscope which was unsuccessfully tried out at the Vienna Hospital, its value not being appreciated until Nitze brought out his electric cystoscope in 1876, the mechanical imperfections of which were overcome by Joseph Leiter of Vienna in 1879, to whom Nitze gave full credit. In 1887 Nitze put out his cystoscope with an incandescent lamp, and in 1889 Boisseau de Rocher first made a cystoscope for double catheterization of the ureters and irrigation of the bladder.

The Buerger, and McCarthy and Young cystoscopes are of similar construction and consist of four parts: the sheath, the obturator, the observation telescope and the catheterizing telescope. The sheath is a circular tube about fourteen inches long of 24 F or 26 F calibre with a lamp about one-half inch long bent at an obtuse angle, with a window or opening at the point where the lamp screws on the sheath. The obturator fits in the sheath and closes both the window and the proximal end. The observation telescope fits in the sheath, leaving room for irrigation and closes the proximal end tightly so as to prevent the escape of the irrigating fluid. It is fitted with an eye piece, the optical apparatus, and is used for examination only. The catheterizing telescope is for catheterization of the ureters and has an eye piece at its proximal end, a deflector or catheter elevator and a lens system at its distal end; also a central fin which divides the interior of the sheath into two grooves or tubes through which the catheters are passed into the bladder and ureters. On the under surface of the telescope near the eye piece are two metal tubes capped with perforated rubber tips, to prevent the escape of water from the bladder, through which the catheters are introduced into the grooves already described.

There are two sheaths — the concave, carrying the lamp on its concave aspect, and the convex, with the lamp on the convex surface; the latter allows a better view in contracted bladders, or where hemorrhage or pus obscures the field, and is applicable when the internal meatus and posterior urethra are to be examined.

This instrument is also made in size 21 F which is serviceable for young persons and those with small external meati. A small examining cystoscope of 18 F calibre is also made, while cystoscopes for children, with single and double catheterizing tubes are made in sizes 16 F to 12 F, while one for examination only is made as small as size 8 F.

Endoscopes. An endoscope or urethroscope is a circular or oval metal tube open at each end for examination of the urethra or bladder. The illumination is obtained either from reflected light from a head mirror or from a lamp at its distal extremity.

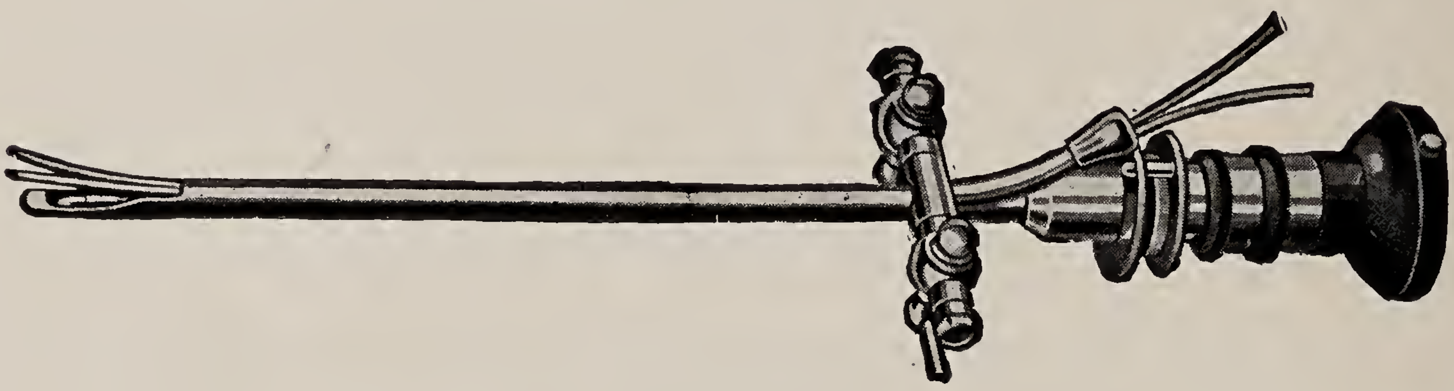

Fig. 1. The McCarthy Miniature Cystoscope.

They were first made by Gruenfeld in 1881 and perfected by Pawlik and Howard Kelly, both of whom popularized the method of examining the bladder and catheterizing the ureters through them.

The Kelly endoscope is a simple circular metal tube with a handle and flared mouth at the proximal end, while the distal end is the same size as the shaft of the tube and is closed, and the end rounded by a snug-fitting obturator. It is difficult to obtain a good view of the bladder, even in the female, but in the hands of those trained in its use, it is quite satisfactory and the ureters can be catheterized with the same degree of accuracy and precision as with the Buerger or McCarthy cystoscope.

Luys has also perfected an endoscope adapted to ureteral catheterization. Luys' urethroscope, as described by the inventor, consists of two distinct parts: 1. The urethroscopic tubes and their obturators; 2. the handle and the light carrier. The shaft of the tube on its under surface has a small groove which holds the light carrier and lamp. Luys says this removes the carrier from the lumen of the tube and gives a larger field of vision. An obturator closes both ends of the shaft, the distal end being blunt and rounded. The tubes are made in two lengths, 14 cm. for the posterior urethra and 7 cm. for the anterior urethra. The calibre varies from 22 to 26 F. At the proximal end of the shaft is a magnifying lens easily movable from side to side in a transverse direction. Owing to the space between the lens and the opening in the tube, instruments can be passed into the urethroscope by the side of the lens. Luys writes enthusiastically about the advantages of his instrument.

Other than the Kelly and Luys endoscopes already described there are many different urethroscopes, both for anterior and posterior urethroscopy.

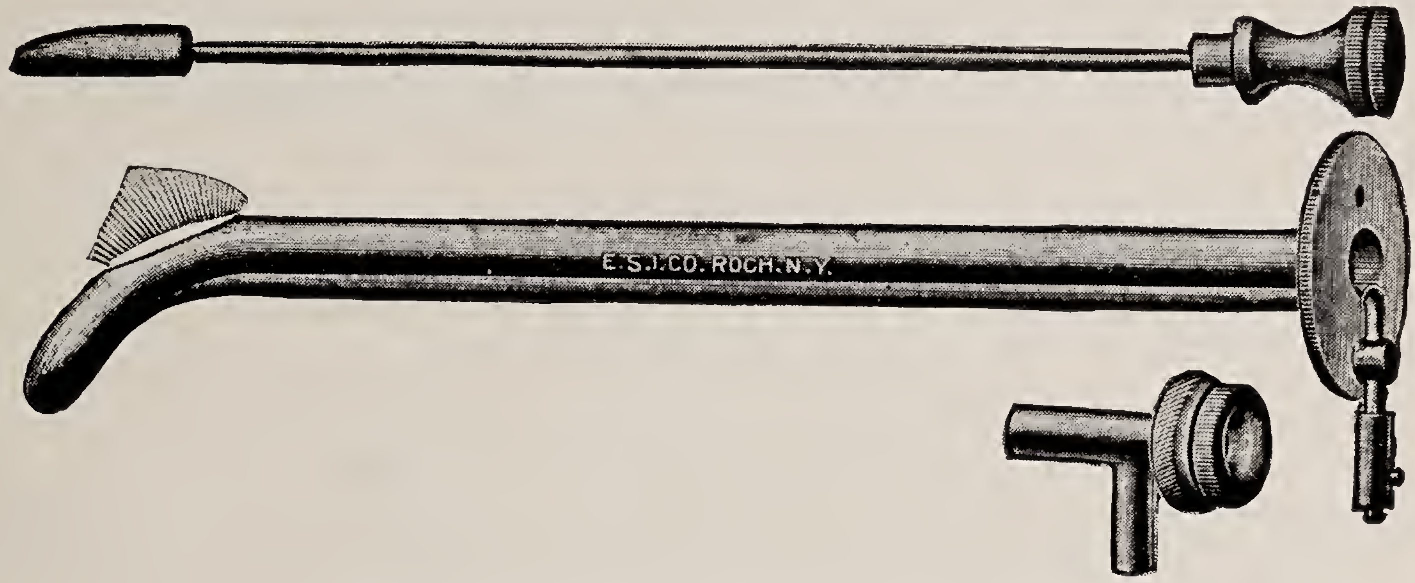

FIG. 2. Swinburne Posterior Urethroscope.

These are of several types: those with the light within the shaft of the instrument near its distal end and those with the light deflected from the outside at the proximal end. There are also simple tubes open at both ends, e.g., the Kelly, the Swinburne, the Young and the Squier, which are without any means of dilating the urethra other than by the distention caused by the instrument itself, and those with air or water-dilating attachments, such as the Gordon, the Buerger, the McCarthy, the Lowsley and the Goldschmidt. The author advises against the use of air-dilating instruments on account of the danger of air embolus.

For simple urethroscopy, anterior and posterior, the author prefers the Swinburne or Young posterior urethroscope, which may be used for both anterior and posterior urethroscopy. For diagnostic use, the water-dilating instruments are best. The Lowsley forward vision urethroscope is very satisfactory, but the McCarthy panendoscope is the peer of them all.

When the simple endoscopic tube is introduced and the light turned on, the urethra being a closed tube, a cone-shaped cavity is seen with striations converging to the point of the cone. With the water-dilating instruments, the urethral walls are forced apart and, if there is no hemorrhage, a clear view of the interior of the urethra obtained.

The Elsner-Braasch cystoscope consists of a circular sheath, an obturator, a lamp at its distal end and a small eye piece fitted only with window glass through which a view of the bladder is obtained through the water that fills the bladder and sheath. Ureteral catheters are passed through special tubes, but it has no guide or deflector as the catheters may be brought into position by moving the beak of the instrument. Except for those trained at the Mayo Clinic, it has not the popularity accorded the McCarthy, Buerger, Young or Lewis cystoscopes.

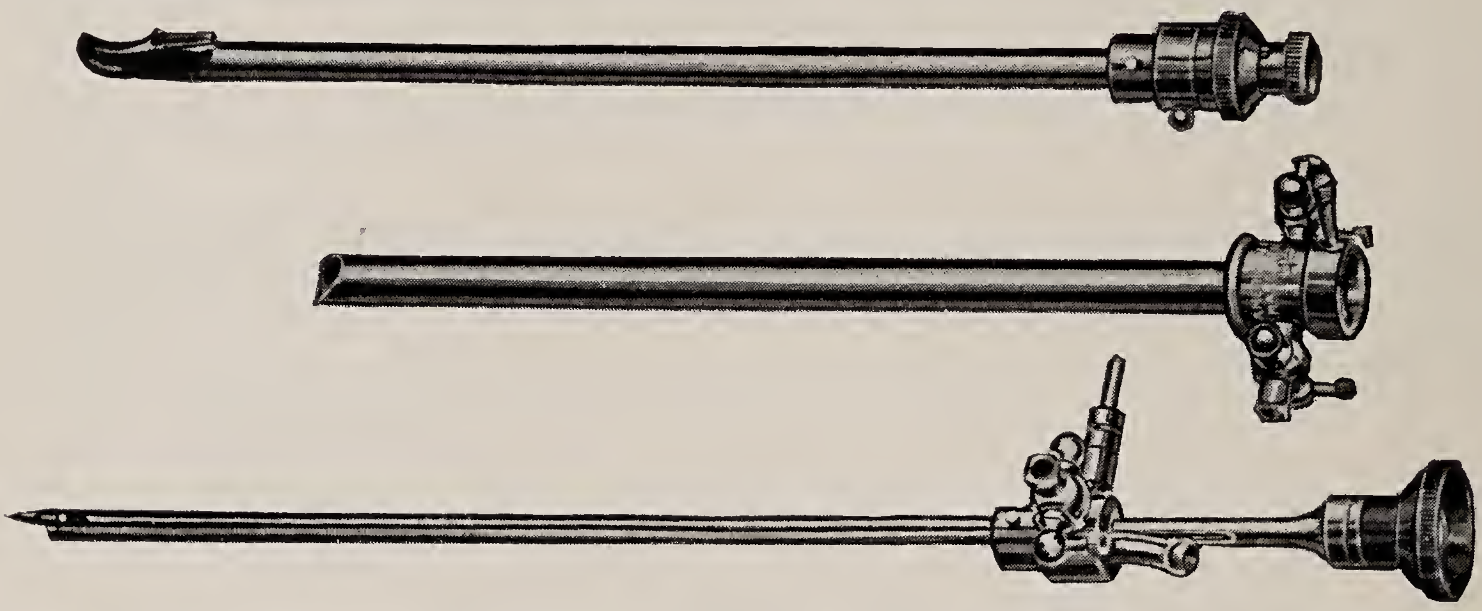

Fig. 3. The Lowsley Urethroscope.

The current to light the lamp of the cystoscope may be obtained from the city electric plant by means of a current controller which screws into any lamp socket and reduces the current to the amount necessary to light the cystoscopic lamp. Dry cells, however, are preferable as they produce a white, brighter light, with much less danger of burning out the small cystoscopic lamp. Then, too, when using fulguration, if the current for the lamp and the fulguration wire are obtained from the city plant, there is great danger of burning out the cystoscope and getting a short circuit which may shock both the patient and the operator, sometimes very severely. This danger is obviated when the cystoscopic lamp is lighted by dry cells. Also, when one has been using an alternating current for his cystoscope and is called to do a cystoscopy in some city where the municipal plant makes a direct current, his cystoscope is useless. When in such a predicament, 3 or 4 dry cells may be connected up and used with perfect satisfaction. The improvement in dry cells, and their universal use, now make possible the easy and satisfactory employment of this method of cystoscopic lighting.

The best means of sterilization of the cystoscope is by use of formaldehyde vapor. Cabinets of various sizes, from simple metal cases to those six or eight feet high, with multiple trays, are now obtainable, with lamps that vaporize formaldehyde tablets or powder. After removal from the vapor sterilizer, the instrument should be placed in lysol, oxycyanide of mercury solution, or sterile water before being used.

Cystoscopy can be done on a kitchen table with the patient's hips brought to the edge of the table and the legs supported on chairs or stools, but it is much more satisfactorily performed with the patient on a specially constructed cystoscopic table. There are many different ones on the market, viz., the Young, Buerger-Hyman, Lowsley, Braasch-Bumpus, Squier, and Kelly-Koett. The author prefers the Kelly-Koett.

Anesthesia. As cystoscopy is a more or less painful procedure, some form of anesthesia is usually necessary. When the bladder only is to be examined, a local anesthetic should be used, but when the ureters are to be catheterized, or operative cystoscopy is performed, some form of opiate, sacral, or general anesthesia, e.g., ethylene, should be used. As a local anesthetic, the author has found alypin in 1 to 2 per cent. solution the most satisfactory and the least toxic. Novocaine in 2 to 4 per cent. solution may be used, but the anesthesia is not so good although the addition of sodium bicarbonate improves it. Diothane $\frac{1}{2}$ to 1 per cent. and butyn 2 per cent. may also be used. Of the newer local anesthetics, methycaine and nupercaine produce very satisfactory anesthesia. Sodium amytal grains 3 to 6 given orally will frequently obviate the necessity of any local anesthetic, though in some cases it causes excitation that requires morphine to quiet. Evipal intravenously usually produces satisfactory anesthesia for 15 to 30 minutes, but may be followed by a stage of excitement. Barringer has added novocaine or alypin to lubrichondrin or K. Y. jelly with satisfactory results, and Bransford Lewis deposits an alypin or novocaine tablet in the prostatic urethra with a special tablet depositor.

In very irritable bladders, especially in tuberculous cases and in operative cystoscopy, sacral anesthesia is the ideal form of anesthesia. A suppository of opium grains 1, belladonna gr. $\frac{1}{2}$ is given one hour before cystoscopy by Corbus and others, and great claims are made for it. The pain of cystoscopy varies with the patient and in the same patient one cystoscopy may be followed by excruciating renal colic, chills, fever, nausea and vomiting, while another of the same character may cause little or no pain.

Solutions. The bladder must be filled or partly distended with a clear fluid in order to obtain a view with the telescopic cystoscope. The medium best adapted for this purpose is sterile 4 per cent. boric acid, though sterile saline or water may also be used. As the fluid has frequently to be changed or replenished, it is best obtained from an irrigator, although some urologists use a large syringe.

Ampules of both phenolsulphonephthalein and indigo carmine should be at hand to test the functional output of the kidneys and locate the ureter openings in difficult cases. After injecting indigo carmine intravenously to locate the ureter openings, phenolsulphonephthalein may be injected and the functional output of the kidneys determined, the blue stain in the urine having no detrimental effect on the accuracy of the p.s.p. test (McCarthy).

Ureteral catheters. These are made of woven silk and a composition of lead or bismuth and vary in size from #3 to #16 F. They have various tips: olivary, ending in a small olive-shaped tip with one or two holes near the end; a diagonal or whistle-shaped tip with a hole in the end and several on the sides near the tip, or they may end in a rounded tip with no hole in the end but one or more on the sides near the tip. The tip is a matter of personal preference, but catheters with the olivary tip are more likely to pass contracted areas, strictures, or stones, but usually do not drain as well as those with the whistle tip. A #6 catheter is the one most frequently employed, though a #5 or #4 may have to be resorted to, and at times even a filiform bougie may not pass some obstruction or a spasm of the ureter. In testing the functional output of the kidneys and in pyelography, a Garceau catheter, one that tapers to the tip, is to be preferred, as it prevents the escape of fluid between it and the ureteral wall. The Blassucci catheter has a filiform tip and is especially serviceable in stricture or stone in the ureter.

Lubricants. No oily substance should be used to lubricate a cystoscope on account of the danger of infection; therefore, a water-soluble lubricant should be chosen. The author has found K. Y. or lubrichondrin, Mulfords or glycothymoline lubricant equally serviceable.

Syringes. A 5 or 10 c.c. glass Luer syringe with needles to fit the various sized catheters, and an asepto 1 to 2 oz. syringe for injecting alypin into the urethra are all that is needed. Bransford Lewis has devised a special tip on an asepto syringe that serves admirably for injecting the catheters. There are also adapters of both rubber and metal that are equally serviceable. Perforated rubber tips, through which the catheters enter the catheter canals, should also be at hand and the Furniss cystoscope-holder to steady the cystoscope and hold the collecting tubes may also be of service.

Preparation for cystoscopy. In order to successfully perform cystoscopy, the following instruments and accessories should be prepared: A McCarthy cysto-urethroscope, Brown-Buerger, Bransford Lewis or Young cystoscope combining examining, catheterizing and operating features, and catheters of various sizes and tips. The cystoscope to be used should be removed from the formalin sterilizer and placed in sterile water or oxycyanide solution; the patient's genitals should be scrubbed with soap and warm water, and then with bichloride or lysol solution. The local anesthetic should be injected and cotton on an applicator should be wet with 2 per cent. alypin and passed into the external meatus. The position previously described is the one preferred by the author, but stirrups with sockets for the knees that flex the thighs at 90 to 120 degrees are preferred by some.

The instrument is introduced into the male urethra in the same manner as in the passage of a sound. When the tip reaches the bulbo-membranous urethra by depressing the ocular end, the tip is elevated and enters the membranous urethra. Should it hang here, due to spasm of the compressor urethrae muscle, the introduction of the index finger into the rectum and upward pressure on the tip of the cystoscope usually causes it to pass on into the membranous and prostatic urethra and then into the bladder. The passage of a cystoscope into the female urethra and bladder is a very simple procedure. The obturator is then removed and the urine allowed to escape from the bladder. The telescope with catheters in their canals should be fitted into the sheath and the bladder comfortably filled through the irrigating cocks. The examination of the bladder may now be done. It is a good idea to divide the bladder into the dial of a clock and take it systematically, going over every inch of it. The kind of instrument makes a difference in the view and manner of examining the bladder, but the picture is the same, the convex instrument giving a more comprehensive view than the concave.

In examining the bladder, the beak should be carried to the posterior wall, then brought forward till the inter-ureteric ridge comes into view; i.e., a fold of mucous membrane connecting the ureteral orifices. In the normal bladder this is easily seen, especially as it is usually raised above the surrounding floor and is more vascular and of darker color; but in the diseased and inflamed bladder it may be more difficult to find. If this ridge is in the center of the field of vision, by rotating the shaft 20 to 30 degrees the right or left orifice comes into view. The color of the normal bladder is a pale yellowish pink and numerous small blood vessels are more or less prominent. In the dome of the bladder may be seen an air bubble which is the air introduced through the sheath, and it always rises to the upper limits of the fluid.

The catheterization of the ureters is usually not difficult. After locating the orifice, the catheter tip is pushed forward until it comes into the field of vision. With the tip of the catheter and the orifice both in view, the beak of the instrument is manipulated so as to bring the tip of the catheter in line with the orifice; the catheter is then pushed forward till it engages and is then passed on up the ureter. Some text-books advise pushing the catheter into the orifice by a forward movement of the cystoscope, but the author prefers to make the proper alignment by means of the cystoscope and then push the catheter itself into the orifice. In some cases the catheter slips over the orifice instead of entering it, especially in those patients in whom the orifice is on the inner side of the interureteric ridge or on a prominence, or is somewhat stenosed.

In order to guard against mistakes as to which catheter has been passed to the right or left kidney, it is wise to use catheters of different color or markings, or, as is the author's custom, have the end of the left catheter cut diagonally and that of the right one square.

Orifices differ in appearance, some being well-marked grooves, some small dimples and others mere slits, while still others are covered by a thin fold of mucous membrane which almost completely hides them from view till they open to discharge urine.

After the ureteral catheter enters the ureteral orifice, it usually passes easily to the kidney pelvis. However, when the orifice is contracted, stenosed or strictured, it may be quite difficult or impossible to make the smallest catheter or even a filiform enter it. Spasm of the ureter, especially in the intramural portion, occurs occasionally and is one of the most difficult complications to overcome. When it occurs, if it will not yield to novocaine or alypin injections and very gentle manipulations, it is best to remove the cystoscope and catheters and attempt it again in a few days. During the interval, the patient should be given fl. ext. belladonna M X or atropine gr. 1–200 4 times a day. Benzyl benzoate in jelly capsules (benzylets) may also aid in relaxing spasm. Continued attempts at catheterization when spasm is present result in trauma or hemorrhage. Later edema also occurs which may close the orifice completely, giving rise to back pressure and stasis which may be followed by pyelonephritis or pyonephrosis if drainage is not promptly instituted.

CYSTOSCOPES OF TODAY

The Kelly cystoscope. The Kelly cystoscope or endoscopic tube, already described, is best adapted for use in the female. The patient must be in the knee-chest position and the bladder empty. The endoscope is introduced into the bladder and the obturator withdrawn. Air enters through the tube and distends the bladder. The urine must be mopped away with cotton swabs. The light is reflected from a head mirror. Its disadvantages are the awkward position for the patient, the difficulty of clear vision and the dexterity needed to use it satisfactorily.

Its advantages. To those who are expert in its use it answers the purpose as well as do the instruments with a lens system; it is less complicated, has no breakable parts, may be sterilized by boiling, requires no irrigation and the field of vision is not magnified. It is eminently satisfactory for applying topical applications to the bladder and for obtaining sections of bladder or urethral tumors for microscopical examination.

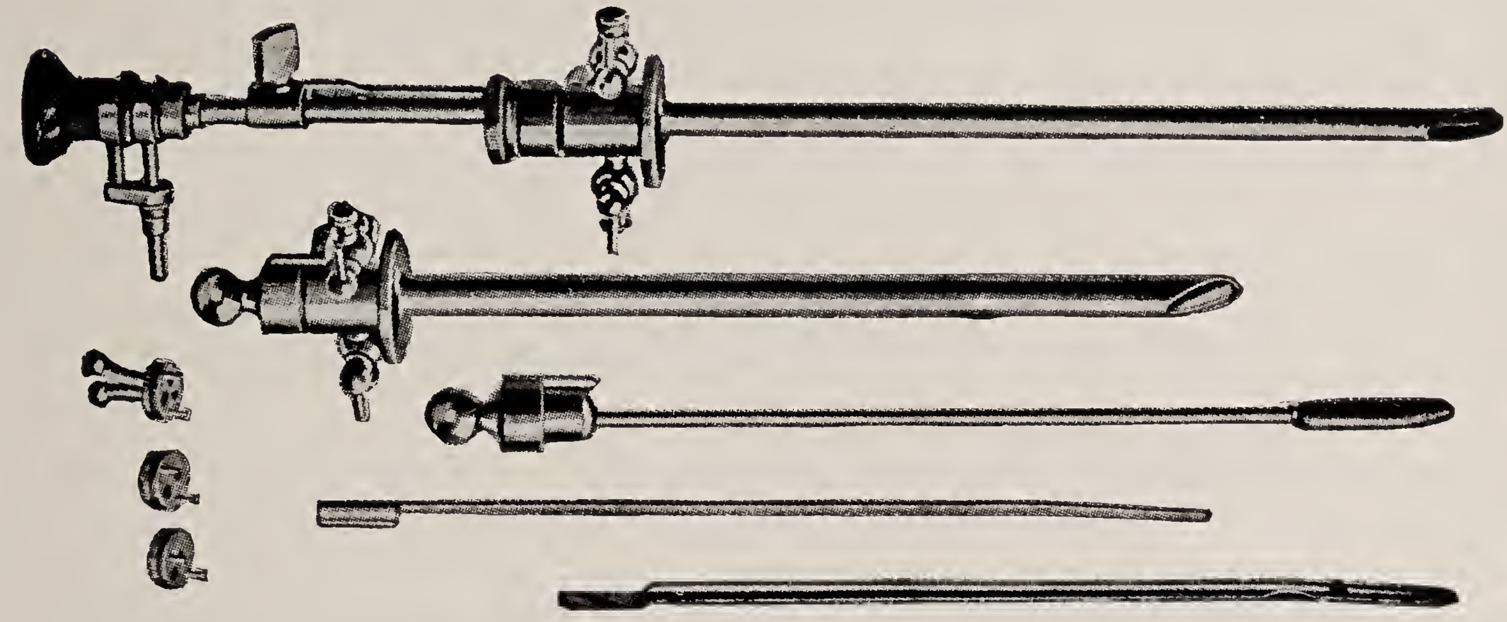

FIG. 4. McCarthy Foroblique Panendoscope.

The McCarthy panendoscope. The McCarthy panendoscope or foroblique cystoscope is the most perfect piece of cystoscopic equipment that has ever been invented. It may be used for a urethroscope and in this field it stands alone, as it gives the clearest, most accurate and comprehensive view of any instrument. It may also be used as an examining cystoscope, as a catheterizing cystoscope, and last (and here, it is in a class by itself) it may be used as an operating cystoscope, permitting the use of larger and a greater number of instruments than any other cystoscope. It consists of a sheath made in two sizes: 24–28 F, with obturators to fit. The sheath is open at both ends, the distal end being diagonal. A telescope with an eye piece about 2½ inches from the proximal end of the shaft is made to fit in the shaft. The telescope closes the proximal end of the shaft and carries a small lamp at its distal extremity that lies on the floor of the shaft near the diagonal tip. Metal troughs of 2 sizes are adjustable to the telescope, for the carrying of instruments, catheters, et cetera, to the bladder and ureters.

The instrument is introduced into the urethra with the obturator in place and when the compressor urethrae muscle is reached, gentle pressure and depression of the proximal end will make it enter the membranous urethra and then pass into the bladder. If we desire to examine the urethra, the obturator is removed and the telescope fitted in place. With the water flowing, the bladder is distended, and by withdrawing the tip of the instrument, the internal meatus, prostatic urethra, veru, membranous and penile urethrae can be examined. The telescope is then removed and the obturator put in place before the instrument is pushed back into the bladder, as the distal end is oblique and may damage the urethra if it is not closed by the obturator. After the tip is in the bladder, the telescope is introduced, and the bladder and ureter openings inspected, the ureters catheterized, or any cystoscopic operative work done. In dilating strictures of the ureter, larger catheters or bougies can be used than with any other cystoscope.

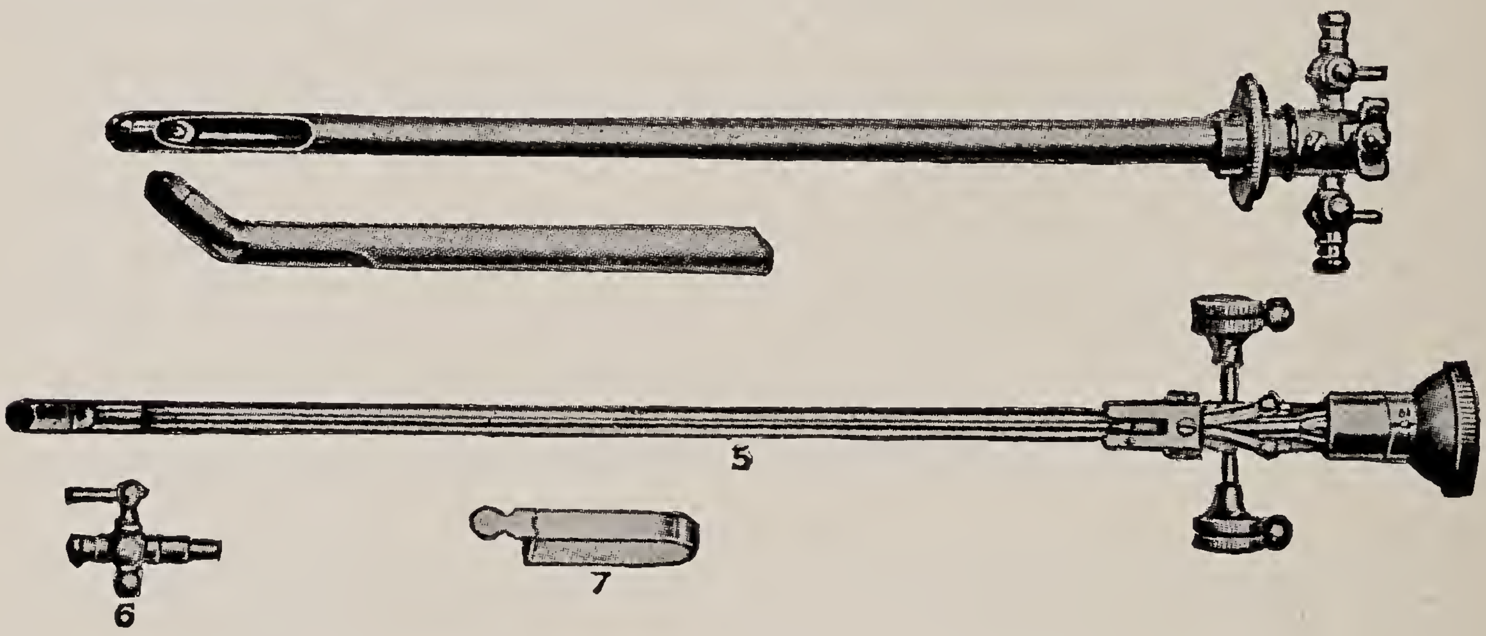

Fig. 5. Buerger Examining and Double Catheterizing Cystoscopes.

The Buerger catheterizing cystoscope. According to Buerger, this instrument consists of four parts: the sheath, the obturator, the observation telescope and the catheterizing telescope. The sheath is circular on cross section, bears a short lamp at its end and possesses a large fenestra or window behind the lamp. The calibre is about #24 F. The obturator closes the working aperture perfectly. The observation telescope is larger but does not completely fill the sheath, room being left for irrigation. The catheterizing telescope combines in one piece the optical apparatus, the mechanism for deflection and the catheter grooves or beds. At the ocular end, there are two catheter channels through which the catheters emerge. These are provided with rubber tips or nipples that firmly grasp the catheters and prevent the escape of fluid from the bladder. A deflector or catheter lift is implanted near the objective.

The Buerger operating cystoscope. This, according to Buerger, resembles the catheterizing cystoscope, but its sheath is elliptical and its telescope provided with a single outlet. Both the catheterizing and operating cystoscopes are provided with convex and concave sheaths, the convex for a direct view, the concave for indirect. The convex is the more serviceable as the prostatic urethra may be examined and treated as well as the bladder.

The Buerger combination observation catheterizing and operating cystoscope. Buerger says, "This instrument, at first glance indistinguishable from the others, offers the possibility of introducing examining, catheterizing and operating telescopes into the same specially designed sheath." For observation and catheterizing, it is as satisfactory as the catheterizing cystoscope, but for operating purposes it will not permit the use of instruments as large as the operating cystoscope.

The Young and Lewis cystoscopes are equally as serviceable as those already mentioned.

Operating instruments. Forceps for various purposes — grasping, cutting, and removal of pieces of tissue — are made with handles like scissors that open and close the jaws. Scissors are also made for cutting the ureteral orifices. If made with a flexible shaft, they are very unsatisfactory, but the modification as introduced by Bumpus, with a rigid shaft, makes a clean-cut incision that is all that could be desired. Bumpus' scissors cannot be used through the Buerger instrument, but are very satisfactory through the panendoscope of McCarthy.

The Walther dilator with adjustable bulbs for dilating strictures and promoting the passage of ureteral calculi, is a flexible metal shaft with a filiform attached to its distal end. It is about a #7 F, and bulbs of various sizes can be attached between the shaft and the filiform for dilating the ureter to any desired dilation.

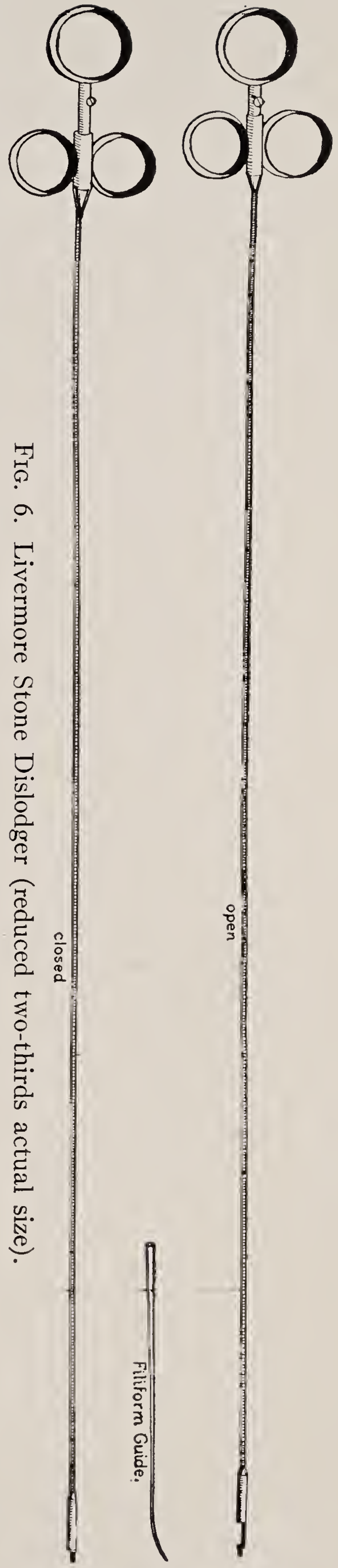

Fig. 6. Livermore Stone Dislodger (reduced two-thirds actual size).

The Livermore stone dislodger has a flexible shaft with a filiform attached as in the Walther dilator, but at the distal end of the metal shaft is a mechanical device that, when opened, leaves only a thin blade of metal on one side between the filiform and the shaft. Thus a slot is left in which the stone may be caught, and by rotating the instrument the metal blade separates the stone from any attachment to the ureteral walls. The instrument is then closed, pushed beyond the stone and removed.

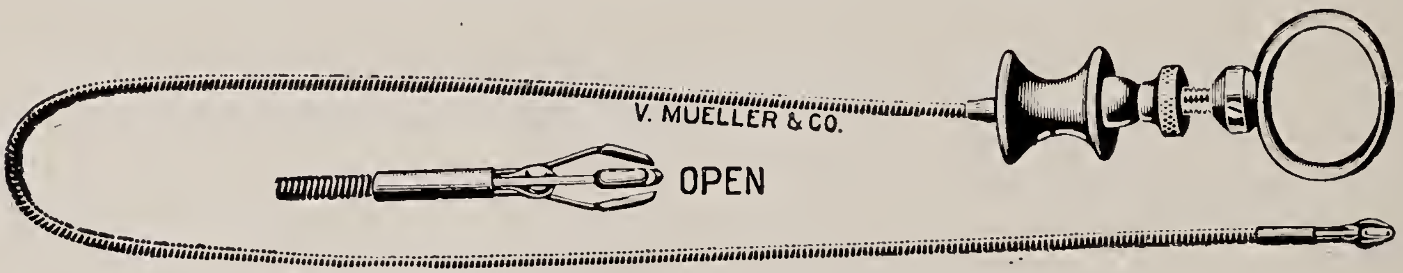

Fig. 7. Livermore Ureteral Dilator.

The Livermore ureteral dilator for ureteral dilation, especially in promoting the passage of calculi in the lower ureter, is made with a similar flexible shaft and at its distal end 4 blades approximate to form a conical tip. A mechanism is provided so that when traction is made on the handle at the proximal end, the blades are separated, making the tip much larger. It is a #11 F when closed and a #17 F when expanded to its largest diameter. The ureter must be dilated with bougies to size 11 F before the Livermore dilator is used. This instrument has proven very satisfactory in the hands of the author.

Cystoscopes for implanting radium in the bladder and prostate have been devised by Young. Radium applicators that may be used through the McCarthy and other cystoscopes are, however, now obtainable.

Lowsley's cystoscope for removing foreign bodies, pieces of tissue, small stones, et cetera, from the bladder, is similar in construction to the McCarthy and Buerger observation cystoscope, but the upturned beak has two jaws which may be opened and closed by a mechanical device similar to the handle of scissors.

Young's cystoscopic ronguer, for similar use, consists of a grasping forceps and a lens system. The opposing faces of the blades are concave so as to form an oval cavity when they are closed. They are opened and closed by means of a scissors-like handle. It is a very useful instrument.

Kretschmer's modification of Young's cystoscopic ronguer consists in having the grasping blades made solid, and their opposing surfaces are flat and fitted with small spikes that make it more suitable for crushing stones.

The Kirwin lithotrite, and the Ravich lithotriptoscope for crushing stones in the bladder are both very satisfactory instruments. Dourmaskin, too, has added a device for dilating the prostatic urethra that he finds aids greatly in treatments to this portion of the urethra.

Butterfield baby cystoscope. An instrument devised by Butterfield, of New York, for cystoscopic examination of children. It may be used in both boys and girls of almost any age. It is size 15 F and has a connection for irrigating the bladder and is adapted for double catheterization. Two #5 catheters pass easily through it. As it has no elevator to guide the catheters, it is somewhat difficult in some cases to make the catheters enter the ureteral orifice, especially after one catheter has been passed. In cystoscoping children, it is best to pass a small sound first, especially in boys, in order to dilate the urethra and make the introduction of the cystoscope easier and less likely to produce trauma. The Sprenger cystoscope is only 14 F and is similar to the Butterfield. McCarthy, Young and Corbus have also devised cystoscopes for use in children.

The author has added a water-conducting device to the Wolf cystoscope. This instrument is the only one for children provided with a catheter elevator and guide. He has found it the most satisfactory infant and child cystoscope he has ever used. With it children may be quickly and easily cystoscoped. Young in his *Urology* says, " in boys under 4 years of age, it is practically impossible to introduce a small child's cystoscope and catheterize the ureters." The author has cystoscoped with ease and catheterized the ureters of a baby boy three weeks old and a baby girl three days old. Children can be cystoscoped with the same degree of precision and ease as adults, and with much less reaction. The only contraindications are a patient too ill or a low p.s.p. and a high blood nonprotein nitrogen and creatinin.

Instruments for transurethral resection of the prostate are included in the chapter on hypertrophy of the prostate.

TABLES FOR CYSTOSCOPY

The successful performance of cystoscopy often depends upon the position of the patient; therefore, a good cystoscopic table is essential. There are many on the market and one's preference depends, as in the case of the cystoscope, with one's training and experience. The author prefers the Kelly-Koett.

The Lowsley cystoscopic table is simple in construction, very practical and satisfactory and has the advantage of being much less expensive. The author has used this table in Lowsley's clinic (The Brady Foundation, New York Hospital) and found it highly satisfactory in every respect.

The Kelly-Koett table is made with adjustable knee stirrups and the head or hips can be raised or lowered as desired, the adjustments all being within easy reach of the operator, and the x-ray tube fixed so that the same relative position is maintained regardless of the position of the table.

The Braasch-Bumpus table is a very good one, the one fault being that the patient has to be moved upward for the x-ray after the ureters have been catheterized.

The Young and Squier tables are also splendid ones. In fact, it is almost impossible to make an error in buying any of the above tables and it is really a question of which table the urologist has used in his training as to the one he prefers.

The art of cystoscopy cannot be learned from a book. It must be acquired by practical work in an office or clinic, under a competent instructor where the student is allowed to perform cystoscopic examinations himself. It is usually an easy matter to learn to pass a cystoscope and catheterize the ureters in the average case, but in some cases spasm of the compressor urethrae muscle or the internal sphincter will not allow the cystoscope to enter the bladder, and in still other cases spasm of the ureteral orifices or the ureter itself will not allow the catheters to pass to the kidney pelvis. The former, occurring only in the male, may be overcome by the injection of alypin 2 per cent., metycaine 2 per cent. or butyn 2 per cent., and the introduction of the finger in the rectum as a guide. The latter, occurring in both sexes, is usually very difficult to combat, and if it will not relax after the injection of alypin 2 per cent. through the catheter and the administration of adrenalin M X hypodermically, it is safer to postpone any further attempts at catheterization, as edema of the ureter may result from the trauma.

The making of functional tests — ureterograms and pyelograms — and the interpretation of the findings, and, finally, operative cystoscopy can only be learned by careful, painstaking study and hard work in a clinic where the student is given individual instruction.

THE NORMAL BLADDER

The mucosa of the normal bladder is of a pale yellowish-pink color. It is more or less smooth, with two ridges radiating outward and backward from the bladder neck. These are the ureteral ridges and on the posterior extremity of each, and usually somewhat more elevated, is the orifice of the right or left ureter. Connecting the two orifices is another ridge called the inter-ureteric ridge. It is usually of somewhat darker color and more vascular than the rest of the bladder. The triangular area bounded by these ridges is called the trigone. Numerous small blood vessels may be seen traversing it, seeming to radiate outward and backward from the bladder neck. The prominence of these ridges varies in different individuals, being usually more prominent in men. In some women, the bladder is so relaxed from childbirth, or misplacement of the uterus, that this ridge may be scarcely perceptible.

It is essential that the student familiarize himself with the normal bladder before attempting to diagnose the pathological one. When the cystoscope is withdrawn till the prism is in the bladder neck, we see a more or less circular ring thrown into irregular folds, which in women are more prominent than in men. The mucosa of the bladder neck is usually redder than the rest of the bladder and the vessels quite prominent. The portion of the bladder beyond the trigone is similar to the trigone, although less smooth and the vessels run in an irregular manner. In the dome is an air bubble which always appears at this point and is the air in the cystoscope that is carried into the bladder by the distending medium and rises to the upper limit of the fluid as the bladder fills.

THE PATHOLOGICAL BLADDER

THE INDICATIONS FOR CYSTOSCOPY

All diseases of the bladder and ureters and all surgical diseases of the kidneys should be given the benefit of cystoscopy, and even doubtful cases should not be denied the one thing that may result in recovery or at least knowledge of the true state of affairs.

The contra-indications for cystoscopy are found in those cases where it is impossible to introduce the cystoscope — deformity, impassable stricture of the urethra, certain types of hypertrophy of the prostate or calculi; in those who are very debilitated either from age or disease, especially where the blood urea and creatinin are high and the kidney function poor. It is well, too, to be very careful in cystoscoping persons with organic heart lesions which are decompensated, or at times partly so, as sometimes following cystoscopy there may be a pronounced reaction, with rigors and high fever, which may result in death. The author has had one such case, where death occurred from acute cardiac dilatation from persistent vomiting, although no rigor or fever resulted.

When there is an active gonorrhea or even a chronic case, cystoscopy should not be done unless the information to be gained or the help hoped to be administered overbalances the danger of the damage that might result. In no case of gonorrhea should a catheter be passed into the ureter unless one is firmly convinced that gonococci have invaded the kidneys

— such a rare condition that the author has never had a personal case in 25 years of practice.

The very irritable bladder is a contra-indication for cystoscopy, but this may usually be overcome by preliminary medication and irrigation; but failure to relieve may be overcome by gas or ethylene anesthesia, or better still (and in tuberculosis of the kidney and bladder it is ideal), sacral anesthesia. In highly nervous individuals and in children, cystoscopy is contra-indicated but this is easily overcome by general anesthesia in children and either sacral or general anesthesia in adults. Meredith Campbell advocates the use of sacral anesthesia in children.

It may be difficult to differentiate inflammation of the bladder mucosa by the degree of redness, especially to the inexperienced, but there are two indications which make it easily discernible: (*a*) increased size, multiplicity and prominence of blood vessels; and (*b*) complete absence of same.

In the former, the engorgement of the vessels is greater than the inflammation of the mucosa, while in the latter the congestion of the mucosa obliterates the vessels. In the more advanced cases the mucosa has a granular appearance — the so-called granular cystitis. In the obstructive types, such as hypertrophy of the prostate or stricture of the urethra, there is edema and thickening of the mucosa which is a dull reddish-pink color, the so-called velvety cystitis.

Ulcer of the bladder varies with the type. The simple ulcer may be a whitish area simulating the appearance of the buccal mucosa when touched with carbolic acid; or it may appear as an abraded, punched out, localized, granulating ulcer surrounded by a circle of redness. In the more severe cases, there may be a slough hanging to its floor; or in the calcareous type, deposits of urinary salts may be seen in it.

The Hunner or Elusive ulcer is well named, as it usually appears as a small reddened area or a faint yellow crack, so indefinite in the surrounding inflammation as to be almost entirely overlooked. It has several distinguishing characteristics, however, which are that it bleeds, and the mucosa is seen to tear or crack and bleed as the bladder distends, and the pain on the slightest distention of the bladder or touch of an instrument is excruciating.

Leucoplakia is quite rare. Wilhelm describes its appearance as "irregular shaped plaques which vary in luster from white to gray and are surrounded by normal or ulcerated areas. The leucoplakic areas have a silver gray luster which causes them to stand out from the normal mucosa and as a rule no blood vessels are seen in these areas."

TUBERCULOSIS OF THE BLADDER

This usually appears as localized areas of cystitis with or without small ulcers, particularly about one or both ureteral orifices. Especially characteristic is a markedly inflamed mucosa very intolerant to dilation and with hidden ureter openings that, when found, are difficult to catheterize.

THE APPEARANCE AND ACTION OF THE URETERAL ORIFICE IN THE PRESENCE OF INFLAMMATION

In acute or chronic cystitis, the ureteral orifice in partaking of this inflammation may become almost obliterated. If, however, it is more inflamed than the bladder, it may stand out prominently as a reddened pouting slit with edematous edges, or it may be dilated or look like a punched-out round hole in the mucosa. It is a fact that inflammation of the ureteral orifice means pathology of the kidney or ureter or both, but a normal appearing ureteral opening does not necessarily mean that the ureter and kidney are healthy, for often in marked disease of the ureter and kidney the ureteral orifice may appear perfectly normal. The ureteral orifice, too, may be retracted; partly or completely stenosed by ulcerated, cicatrical or edematous tissue, or a segment of the ureter may prolapse through it into the bladder. When there is marked retraction of the ureteral orifice and some induration around it, it may appear as the gaping opening of a tunnel, the so-called " tunnel orifice."

The urine usually is ejected in rhythmical spurts from each ureteral orifice; the mouth may be seen relaxing, the urine gushing out and then the mouth contracting again. The ejected urine may be perfectly clear, cloudy with pus, markedly purulent, or blood stained. In inflammatory conditions, where the muscular tone of the orifice has been impaired, rhythmical relaxation and contraction and spurts of urine do not occur, but the urine is seen to trickle out constantly or at irregular intervals. In certain severe types of pyelonephritis, with or without calculi, thick ropes or cylinders of pus may be seen to exude from the ureteral orifice that resemble tooth paste as it is squeezed from its tube.

PROSTATIC LOBES

The cystoscopic appearance of the hypertrophied prostate depends upon the type and degree of enlargement of the prostate. When there is a bilateral hypertrophy the internal meatus appears as an inverted " V " instead of a circle. When the isthmus or so-called middle lobe is enlarged, it projects upward into the internal meatus and therefore we see the normal circular ring of the meatus on one side and the bulging mass of the middle lobe that springs from the floor of the urethra on the other. The cystoscope may be pushed beyond the mass and frequently turned so as to bring the ring of the internal meatus on the other side into view. When one lateral lobe is markedly enlarged and the other only slightly so, the normal concavity of the internal meatus is seen on one side and the convex bulging mass on the other. In the median bar it may be difficult to see the obstruction, but if there is marked elevation of the floor of the internal meatus and the trigone beyond seems to dip considerably, a bar is present. Trabeculation of the bladder and residual urine make the diagnosis certain.

Where there are bilateral and median lobe enlargement at the same time, the internal meatus appears as a small triangle, and there is the bulge of the median lobe below as well as that of each lateral lobe on the sides.

In some cases there may be no prostatic hypertrophy apparent in the internal meatus or bladder and yet there may be marked hypertrophy in the prostatic urethra. It is, therefore, of the utmost importance not only to examine the internal meatus and bladder but also the prostatic urethra. Only the convex lens or the McCarthy panendoscope is suitable for this latter purpose. With bilateral intra-urethral hypertrophy we see a slit in the floor of the urethra with the bulging lateral lobes forming its walls. The verumontanum is seen usually midway between these lateral lobes and is frequently very much hypertrophied, thus adding to the urethral obstruction.

CARCINOMA OF THE PROSTATE

This usually produces no characteristic cystoscopic appearance, though it frequently appears as a bar or contracted bladder neck, which is a lucky thing for the patient as it makes his case suitable for resection or the punch operation, as these are the best methods of treatment for such cases. The so-called typical nodular appearance of the internal meatus is rarely seen. The diagnosis of carcinoma is made by the dense cartilaginous feeling of the prostate per rectum and from biopsy rather than by any typical appearance as seen through the cystoscope.

TUMORS OF THE BLADDER

Tumors of the bladder are benign or malignant, but it is often difficult to differentiate them cystoscopically.

Papillomata. These appear as small, branching-like processes that spring from a single stalk resembling a small tree, or there may be numerous finger-like branches, each springing from the mucosa of the bladder and resembling a bush. It is impossible to determine the malignant from the benign on cystoscopic examination, but it is a safe rule to consider all papillomata as potentially malignant. A method of differentiation is by fulguration, those that respond to fulguration being considered benign and those that do not as malignant. This, however, is not infallible. When the papilloma has a shaggy appearance, with white or gray shreds hanging from it, ulceration has taken place and this indicates malignancy. Often deposits of calcareous particles may be seen clinging to the shaggy mass.

Carcinoma. Carcinoma of the bladder, when sessile, may simulate inflammatory ulceration. Keyes says inflammatory ulcers usually occur about the trigone, while malignant ones affect the vault and fundus. I consider this an unsafe rule to follow.

Carcinoma which involves the bladder from neighboring structures, such as the uterus, may be suspected when the seat of the ulceration is fixed and when there is the appearance of multiple blebs or vesicles on the fixed mucosa, the so-called bullous edema.

Cystitis cystica. Cystitis cystica cystoscopically resembles bullous edema. It occurs as a collection of round clear or yellow vesicles, which have been compared to caviare. They usually occur on the trigone but may be seen elsewhere. They are considered as evidences of inflammation by some observers, but others say they may be seen in normal healthy bladders. The author has only seen this condition in a case of chronic cystitis and it responded nicely to fulguration.

BLADDER CHANGES DUE TO PREGNANCY

Cystocele and obstruction. When pregnancy occurs, as the uterus enlarges it encroaches upon the bladder, pushing it forward and crowding the posterior wall towards the anterior. In the later months of pregnancy, there is marked obstruction to the cystoscope so that the beak must be carried to the right or left of the bulging uterus. The mucosa is also somewhat thickened and edematous. When a cystocele is present, the floor of the bladder falls down into the vagina, leaving a pouch behind the internal meatus, and hence the ureter openings are difficult to find. The beak of the cystoscope must be depressed and the eye piece carried well forward and upward to locate them.

Obstruction to the vesical orifice or urethra is soon followed by changes in the bladder and ureters. Chronic cystitis, with reddening and thickening of the mucosa soon occurs, often producing a smooth, thickened, velvety appearance of the mucous membrane — the so-called velvety cystitis. The mucosa may also become edematous, either localized or generalized; and at times, bleb-like masses of edema occur, the so-called bullous edema. Trabeculation also is frequently seen. This appears as thickened bands with thinned-out or flabby areas between. It resembles the irregularity produced by the roots of trees growing just beneath the surface of the ground.

In some cases there are distinctly sacculated areas between the trabecular bands, the so-called saccules; and in still others, the constant back pressure acting upon a congenitally weak area may produce a diverticulum. This appears as a round dark hole or orifice in the bladder wall, into which the beak of the cystoscope or a catheter can be passed. The size and extent of a diverticulum can only be determined by a cystogram. This is made by filling the bladder with an opaque substance, such as neo-silvol 25 per cent., sodium iodide 8 per cent., et cetera, and then taking an x-ray of the bladder. It is best to make several plates: one with the patient on the back, one with the patient on the abdomen, and one with the patient partly on the side.

VESICAL CALCULUS

Stones in the bladder are usually easily distinguishable with the cystoscope, but they may be discolored or covered with mucous and pus, rendering them somewhat difficult to differentiate from sloughing tumors or ulcers, especially as both tumors and ulcers may have encrustations on them. Their motility and the peculiar click of metal against stone when the beak touches the calculus will usually serve to prove the diagnosis of stone. Bladder stones do not always cast a shadow on the x-ray plate, hence, the importance of cystoscopy; but when the stone is in a saccule or diverticulum, or where there is marked hypertrophy of the prostate, the stone may readily be overlooked.

CATHETERIZATION OF THE URETERS

Catheterization of the ureters is performed as an aid in diagnosis and as a means of treatment to the kidneys and ureters. Both ureters should be catheterized, because, although the symptoms may point to the left kidney, the right may be the seat of the disease or both may be affected, and it is essential to know the condition of both kidneys in every case.

In the well-equipped office, with bath and rest rooms, cystoscopy is a safe procedure, but it is best for the patient to go to a hospital following it for rest and care, as marked reaction with severe renal colic, nausea, vomiting, chills, fever, and suppression of urine may result.

It is especially necessary to know the blood urea and creatinin and phthalein output where serious kidney impairment is suspected in children and elderly people. Keyes states that he has known death to occur from cystoscopy and I, too, have known it to occur twice. We make it a rule to give these patients glucose and soda per rectum following cystoscopy, and digitalis and caffeine sodio-benzoate if the pulse becomes weak or rapid and the urinary output is diminished.

Ureteral catheters are of various sizes, #4 to #8 F, and have various tips, whistle or flute, a smooth oblique tip, with an opening in the end and one or more on the side near the tip; olivary, with a tapering end, with an olive or oval knob at its tip. The openings are on the side near the tip.

There are also Garceau catheters, 7 to 15 F being large about two thirds their length, then tapering to a small tip with an eye in the distal end and one or more in the sides near the tip. Blassucci catheters are similar to Garceau except that instead of tapering for their terminal one third, they are of regular size and the tip armed with a filiform to facilitate the passage through a stricture or past a stone. An olivary-tipped catheter or a Blassucci may enter a ureter where a whistle or other tip will fail. The flow from an olivary-tipped catheter is usually not so free as that from a whistle-tipped or Garceau. Catheters may be graduated in centimeters or plain, the usual distance to the kidneys being from 18 to 24 centimeters.

Ureteral catheters should be passed gently and slowly, remembering that the ureter perforates the bladder diagonally and that there is a sphincteric action to the orifice; that it then ascends in a forward curve up the posterior aspect of the pelvis, over its brim and upward to the kidney; that it is a muscular tube that is subject to spasm; that the mucosa is so delicate that the gentlest passage of the catheter denudes epithelium and causes some slight bleeding.

When there is no flow from the catheter it may be due to a plugged catheter, to a catheter anuria (the presence of a foreign body in the ureter and pelvis has acted reflexly to stop the excretion of urine, usually only temporary), to obstruction of a stone or kink, or to a non-functioning or dead kidney. Sometimes the flow may be started by the injection of a few c.c. of sterile saline or water. Fluid should be injected very gently, preferably through a spinal manometer at not more than 50 mm. of mercury pressure, and should be discontinued at the first sensation of fullness or pain in the kidney region. After the catheters are in the pelvis of each kidney, the cystoscope may be removed and the specimens of urine from each kidney collected in separate sterile test tubes. In removing the cystoscope, the catheters should be pushed into the bladder in order to have some slack in the bladder so that if traction is made on the catheters in withdrawing the cystoscope, only the slack will be pulled out and their position in the ureters be undisturbed.

Collect about 2 or 3 c.c. of urine from each kidney for microscopical examination, then collect more in new tubes for cultures and guinea pig inoculation. This is especially important as most catheters are cleansed by siphoning bichloride of mercury solution or oxycyanide through them and after washing with sterile water, sterilized in formalin vapor. Therefore, the first urine collected may contain enough antiseptic to prevent the growth of bacteria, despite the injection of sterile water prior to their use; hence, the value of second specimens after the first have cleared the catheters of bichloride and formalin. After the specimens for microscopical examination and culture have been obtained, the patient is given a glass of water and phenolsulphonephthalein 6 per cent. (which can be obtained from any of the pharmaceutical houses) is injected intravenously. All urine that comes from each catheter for 15 minutes is collected in separate tubes into which one or 2 c.c. of 15 per cent. sodium hydroxide has been poured, which alkalinizes the specimens so that the time of appearance of the phenolsulphonephthalein will be noted the moment its excretion begins, by its red color. The normal output of p.s.p. intravenously is about 1 per cent. per minute per kidney, for fifteen minutes.

Indigo carmine is also used to test the kidney function, but is not so universally used as p.s.p. The author uses indigo carmine merely to locate the ureteral orifices in cases where it is impossible to find them without it. When given intravenously it soon appears blue in the urine and the orifices of the ureters are located by the escape of the blue urine coming from them. The use of the indigo carmine in no way interferes with the p.s.p. test, for, although the urine may be stained deep blue, the addition of alkali brings out the typical red color of alkaline phthalein exactly as if no blue color were present. I am indebted to Dr. Jos. F. McCarthy of N. Y. for this valuable suggestion.

Graves and Davidoff have definitely proved that reflux may occur up normal ureters. This is especially true where catheters are in the ureters; hence, it is important to have the patient's head and shoulders somewhat elevated in order to diminish this possibility.

The specimens should be sent to a reliable laboratory for examination and culture and perhaps guinea pig inoculation. A few blood cells mean nothing as there is sufficient trauma, regardless of the utmost gentleness, to account for them. Bleeding from the kidney or ureter is more easily determined by seeing the bloody efflux from the ureteral orifice prior to catheterization.

COMPLICATIONS OF CYSTOSCOPY

These consist of slight lacerations to the mucosa of the urethra, bladder, ureter and kidney which may result in chills, fever and sweats, the so-called urinary fever or the more serious pyelonephritis. These may be minimized or entirely prevented by extreme gentleness, perfect cleanliness and the use of suitable instruments and by the administration of some urinary antiseptic, such as urotropin or cystogen by mouth or intravenously prior to cystoscopy. We have found hexamethylene tetramine gr. 31 given intravenously before or after cystoscopy to be a valuable preventative of rigors and fever. If they occur, it diminishes their severity, and may be given twice daily in addition to 10 grs. 4 times a day by mouth.

Cystoscopy is not a painful procedure except in the presence of an irritable bladder or a small meatus. This is especially true in women. The author can speak feelingly upon this subject. It is uncomfortable but not painful and its discomfort can be minimized by the use of a local anesthetic, alypin 2 per cent., tutocaine 2 per cent., or butyn 2 per cent., and the administration of belladonna or atropine and some bromide or mild opiate one half hour prior to cystoscopy. The after-effects of cystoscopy may be very severe and the pain of renal colic which occurs so frequently is agonizing.

An immediate hot sitz bath, following cystoscopy, soothes the pain and relaxes spasm, but is usually insufficient without an opiate. The administration of alkalies and water is especially important. They may be given in the form of glucose 5 per cent. and soda 2 per cent. solution per rectum or 5 per cent. glucose by hypodermoclysis. Caffeine-sodio-benzoate and digitalis should be given as stimulants should the pulse become weak or rapid, and both are diuretics. It is a fact, too, that patients remaining in the hospital for 24 hours following cystoscopy and failing to have any serious reaction may be subject to violent renal colic, nausea, vomiting, chills, fever and even anuria after returning to their homes.

THE DISEASED URETER

By ureteral catheterization we may detect disease of the ureter, but often other aids are necessary to confirm it. Stone is detected by the obstruction to the passage of the catheter but often, even with large ureteral stones, the catheter passes without any evidence of obstruction. Catheters may be coated with wax and a scratch or scratches obtained when it strikes or passes the stone. This does not always happen, especially in small, smooth stones. The ear-phone catheter of Hagner may also be used to detect the presence of ureteral calculi.

Ureteral stricture is a definite pathological entity and occurs very frequently. A ureteral catheter is of no help in the diagnosis of stricture except when a small-bulbed one passes after a larger size has met obstruction or when the obstruction will not let any size catheter pass. A stricture, however, can only be proved by the x-ray and retention of pyelographic media after 8 minutes, according to Goldstein's findings. The grasping of an instrument (a wax bulb) is of doubtful value, as the grasp of the normal ureter, when spasmodic, may be so great as to simulate stricture.

Dilatation of the ureter is best shown by the ureterogram, and the finding of a constant flow from one ureteral catheter below the pelvis can not be relied upon, as we may have a free constant flow from a ptosed right hydronephrosis with a normal ureter, while the opposite side may have a dilated and kinked ureter, the catheter being so held in the folds of the kink as to be completely obstructed.

ROENTGENOLOGICAL DIAGNOSIS

Of all urological diagnostic methods, cystoscopy stands first, but radiography is a close second. The two combined make urological diagnosis probably the most accurate of any branch of surgery. In order to obtain the best results it is necessary to have modern, up-to-date x-ray equipment, an efficient operator, and last, and by far the most important, an experienced interpreter of the films.

Preparation of the patient. Many urologists think the best plates are obtained when an ounce of castor oil is given the night before and an enema that morning; while others believe that this only serves to increase peristalsis and gas formation. The author believes the best results are obtained by giving the oil and enema two days before and eating light simple food and fruits the day before the examination. If suspicious shadows are seen, then a castor oil purge is necessary to eliminate the bowel contents as the possible cause of the shadow.

One plain x-ray plate may be made of the entire tract before cystoscopy and another plain plate should be made after the catheters have been introduced to each pelvis.

PYELOGRAPHY

This is the method of photographing the outline of the pelvis and ureters by means of an opaque liquid injected through the ureteral catheters. Many substances have been tried out; first, collargol, then thorium, then sodium bromide, then silver iodide, all having some disadvantage, until finally sodium iodide 12 to 15 per cent. was found to be the best and least irritating of them all. However, it is often quite irritating to the bladder. Cunningham has added mercuric iodide, which makes the solution antiseptic. Neo-silvol 35 per cent. solution is also quite satisfactory. It is non-irritating to the bladder, but on account of its thick heavy precipitate, remains longer in the kidneys and may prove a source of irritation to the pelvis and perhaps plug the ureter. A solution which I have devised and found most satisfactory is equal parts of 35 per cent. neo-silvol and sodium iodide 20 per cent.

Pyelography should be used with caution, never injecting both kidneys at the same sitting; injecting preferably using a manometer, and discontinuing at the first sensation of fullness or pain in the kidney region, and never going above a pressure of 50 mm. of mercury as it is a very easy matter to use enough force to cause extravasation of the fluid into the kidney parenchyma.

If the patient has fever a pyelogram should not be made, and where the functional output of both kidneys is poor pyelography is especially dangerous and should be deferred until there has been improvement in the functional output. It is best to inject the pyelographic medium with the patient in the Trendelenburg position, then withdraw the catheters to the lower ureter and elevate to 45 degrees when the x-ray plate is made. By this method, dilatation and kinking of the ureter and ptosis of the kidneys are revealed. The catheters are now removed, the patient lowered to a horizontal position, and after 8 minutes the last x-ray plate is made. This is done to determine the emptying ability of the pelvis, as Goldstein has shown that the normal kidney pelvis empties in 5 to 8 minutes; therefore, retention of pyelographic media after 8 minutes denotes some obstruction to the ureter or pelvis or lack of tone and diminished peristalsis of the pelvis and ureter. A Garceau or Woodruff catheter has proven best for pyelo-ureterograms in the author's hands.

Keyes gives the following rules for pyelography: I. Never pyelograph both kidneys simultaneously. II. Never pyelograph a palpably hydronephrotic kidney unless prepared to operate promptly. The diagnosis of hydronephrosis of any size can be readily made by noting the amount of fluid that flows immediately from the catheter when it reaches the pelvis. III. Never inject by syringe, always by gravity. IV. Watch the inflow closely to observe the moment that the pelvis is filled, before the patient feels the pain of over-distention. V. Keep the patient in bed for at least 4 hours after pyelography. I agree fully with Nos. IV and V. I see no reason for not pyelographing a hydronephrotic kidney unless the ureter is blocked, as the medium can usually easily be drained off by introducing a catheter should untoward results follow. Bilateral pyelograms may be made routinely unless the p.s.p. is low or the blood n.p.n. or creatinin are high.

If the pyelographic medium is injected under too great pressure, the pelvis will be over-distended and serious damage may be produced due to the forcing of the pyelographic medium into the pyramids, lymphatic and venous spaces, resulting in necrosis and infection. Therefore, it is of the greatest importance that no fluid be injected except with the utmost gentleness through the manometer and under a pressure of 50 mm. of mercury or less, and the injection discontinued the moment the patient experiences any sensation whatever in the kidney region.

It is perfectly safe to inject by syringe provided a manometer is used and the pressure is never above 50 mm. of mercury, and we discontinue injection at the first sensation of fullness in the kidney region. The normal capacity of the pelvis varies from 3 to 8 c.c., 5 being about normal.

Pyelography and ureterography should be employed routinely in the examination of urological cases except as above stated.

RENAL CALCULUS

Stones may occur in the kidney, either in the parenchyma or in the pelvis, and the pyelogram is the best method of determining the position of the stone. The shadow also must be differentiated from shadows in the intestinal tract, in the gall bladder, and from those cast by calcified lymph nodes or phleboliths. A castor-oil purge usually differentiates the first; shadows with pale centers and visualization of the gall bladder, stereoscopic and lateral view plates, the second; and the ureteral catheter and the pyelograms the last. Stones that do not cast a shadow may be suspected when there is a lighter oval, or rounded, area (negative shadow) in the pyelogram. Intravenous urography is a valuable diagnostic aid in such cases, as it usually visualizes calculi that do not cast a shadow.

URETERAL CALCULUS

These may occur anywhere in the ureters, but are most often seen in the upper or lower one-third, frequently at the intramural portion of the ureter. They may be confused with shadows in the intestinal tract, with phleboliths and calcified glands and calculus in the seminal vesicle. A good purge removes the intestinal shadows. Phleboliths are differentiated by their round shape, by being usually outside the line of the ureter, and by making two exposures on the same plate with catheters in place and shifting the tube. Bransford Lewis has shown that it is necessary to use a flexible metal instrument in the ureter instead of a catheter to prove conclusively that the shadow is in the ureter. Calculus in the seminal vesicle may be differentiated by palpation per rectum and by vasotomy and the injection of iodized oil and x-ray.

The injection of air into the pelvis and ureter and an x-ray will often bring out the shadow of a calculus in the pelvis and ureter that had previously not shown. There is danger, however, of air embolus, but Thompson has reported 120 cases with no untoward results. He stresses the point that the manometer be used under 50 mm. of mercury or less and that no more than 30 c.c. of air be injected. Intravenous urography, as stated above, is the best and safest method.

VESICAL CALCULUS

Stone in the bladder is usually easily shown by means of the x-ray. The cystoscope, however, is the best means of diagnosis. In cases where it is impossible to pass the cystoscope and where the x-ray fails to show the stone, the injection of some opaque substance (neo-silvol 25 per cent., sodium iodide 8 per cent.) to coat the stone, and then having the patient void, will result in a shadow showing on the second plate. Air injected into the bladder is especially useful in showing the stone, but here again is the danger of air embolus. Intravenous urography is again the best method.

CYSTOGRAPHY

This is the method of injecting the bladder with an opaque substance and taking an x-ray plate. It is used in the diagnosis of diverticulum, tumor and stone in the bladder and hypertrophy of the prostate. Should the ureteral orifices be dilated, some of the medium will pass upward and give an outline of the distended ureters and their orifices.

The media employed are neo-silvol 25 per cent. and sodium iodide 8 per cent. Cystography is especially useful in the diagnosis of diverticulum, for, although we can usually see the diverticulum opening in the bladder, the size, extent and whether attached by a short or long neck can be definitely established only by cystography. It is best to take the first plate with the patient lying prone on his back; a second one, lying obliquely on his side; and a third one, lying on his abdomen. Tumors of the bladder, too, are clearly shown by cystography, especially when air is used, and carcinoma of the bladder, as stated by Keyes, may be distinguished from extensive ulcerative cystitis. The differential diagnosis between infiltrating and non-infiltrating carcinoma of the bladder may also be made by cystography.

The injection of oxygen in the peri-renal tissues seems dangerous to me and several deaths have occurred from its use. It does give a clearer outline of the kidney, however, and may be justifiable where a diagnosis is impossible without it. The author has never used it, and, until made safer, will not. As intravenous urography gives such a clear outline of the kidneys except in the non-functioning ones, it obviates the necessity of using a method that is painful and dangerous.

The injection of carbonic acid gas into the peritoneal cavity to differentiate abdominal from kidney tumors has been used with some success. It is done just as in tapping a patient for ascites. The carbonic acid gas is slowly injected until the patient complains of the distension, and several plates made at different angles. As it is quickly absorbed, the discomfort is only transient.

RENAL FUNCTIONAL TESTS

The tests for renal function are of vast importance in urology and constitute one of the best means at our command for determining the fitness of patients (with urinary tract disease) for operation. The tests, as commonly used by American urologists, are the phenolsulphonephthalein, usually called 'phthalein or p.s.p.; indigo carmine, and urea.

By means of cystoscopy and ureteral catheterization, we are able, by the employment of these dyes and the determination of the amount of the dye excreted in a given time, to accurately judge the condition of each kidney. To make the tests of real value, it is important to use Garceau catheters in order to prevent the loss of a certain amount of the urinary output from each kidney that will leak by the side of the catheter unless it tightly plugs the ureter. Should a small catheter be used (and at times we are only able to introduce a small one) a fairly accurate determination may be obtained by collecting the flow from each ureteral catheter for the specified time, then drawing the leakage from the bladder and multiplying this by the percentage of p.s.p. from each. Thus, if the right kidney output was 10 per cent. and the left 8 per cent., and that from the bladder 10 per cent., ten-eighteenths of 10 per cent. would represent the loss from the right and eight-eighteenths of 10 per cent. the loss from the left. Adding this to the percentage obtained from each catheter would approximate the total output from each kidney.

The dyes used are phenolsulphonephthalein and indigo carmine. These are given intravenously and specimens collected for two periods of 15 minutes each. Some recommend drinking water freely during 15 or 20 minutes prior to the test, while others limit the amount to one glass as the test is given. Either is satisfactory.

The dye should appear in 2 to 3 minutes normally, but might be delayed 5 to 8 minutes; hence, the fallacy of relying on appearance time alone. With indigo carmine, however, the depth of concentration is usually fairly accurate in judging the function of each kidney. In kidneys of good function, the blue color increases rapidly in about one minute to a deep blue; while in those of poor function it continues to remain pale blue even for one half hour or more, then may become darker or continue to be pale, depending upon the condition of the kidneys.

Phenolsulphonephthalein is the most universally used in this country, while indigo carmine holds first place abroad. The latter, on account of appearing blue in the urine, is most used for meatoscopy, although by filling the bladder with sodium bicarbonate solution, phthalein will appear red when the urine escapes from the orifice of the ureter. The author prefers p.s.p. for kidney functional tests but uses indigo carmine to locate a hidden meatus. As stated above the phthalein can be given while the urine is still blue from indigo carmine which in no way interferes with the accuracy of the p.s.p. test. It is also a fact that indigo carmine is decolorized by alkaline urine, which of course may prove a source of error if this is not checked.

An output of 1 per cent. per minute of phthalein for 5 minutes (though I prefer 1 per cent. per minute for 15 minutes) denotes a good kidney and one capable of maintaining life if the other is removed. Rathburn states that if p.s.p. appears within 3 minutes, the kidney is good enough to maintain life alone.

Estimation of urea concentration in separate kidney specimens is of value in judging the condition of the kidneys, but due to its simplicity and ease, the p.s.p. test has superseded it in this country, although in cases of doubt it is safer to use both. A urea concentration of 18 to 20 grams to 1000 c.c. of urine indicates normal kidneys, as the normal daily output is about 1800 to 2000 c.c. of urine, which should contain about 36 to 40 grams of urea.

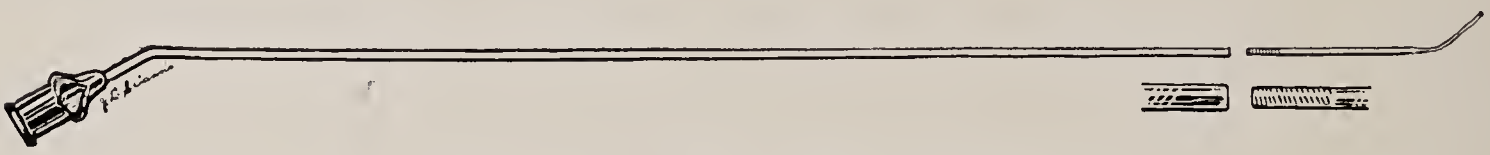

Fig. 8. Livermore Follicular Needle.

As above stated, the passage of a ureteral catheter may produce diminution or complete stoppage of kidney function. It is also a fact that in patients who become nauseated and go into partial or complete syncope during cystoscopy, the kidney function is markedly reduced; hence, one examination of the kidney function is unreliable and must be checked to know the true condition of the kidneys.

Intravenous urography usually demonstrates the function of the kidneys, and the reader is referred to the author's description of intravenous urography, page 1003 (1).

OPERATIVE URETHROSCOPY

These are the operative and remedial procedures that can be applied through the urethroscope.

Operative anterior urethroscopy: Certain procedures, such as applications of silver nitrate solution 5 to 20 per cent., or silver nitrate stick, to granulations, ulcerations, et cetera, or the injection of the lacuna of Morgagni, or the glands of Littré with silver nitrate 20 per cent. solution through the Livermore follicular needle; or the incision of small follicular abscesses with the Kollmann knife; or fulguration of infected follicles with the high frequency current, and the author's method of fulgurating a stricture of the urethra, may be successfully accomplished through the Kelly endoscope, or the anterior and posterior urethroscope of Swinburne, Young, Squier, or the Cameron Surgical Company.

The author has devised a method of fulgurating strictures of the urethra, which, although not always effective, has proved in many cases the best method he has ever used. It is applied by means of a Bugbee electrode through the McCarthy panendoscope or the Lowsley urethroscope. The stricture is fulgurated in the mid-line above and below, and its entire width should be fulgurated.

In a few days the patient returns for a dilatation. We will usually find that a sound, which had been passed with difficulty before fulguration, may now be passed with ease. Subsequent dilatations are more easily and more rapidly accomplished. I have recently used the current of the Collings' electrotome and believe it acts better than the high frequency current.

Operative posterior urethroscopy. For topical application to the veru with nitrate of silver, or carbolic acid, and for the injection of the sinus pocularis with the Livermore needle, or the destruction of papillomata with the cautery or the high frequency current, the Swinburne, Young or Cameron posterior urethroscope is quite satisfactory.

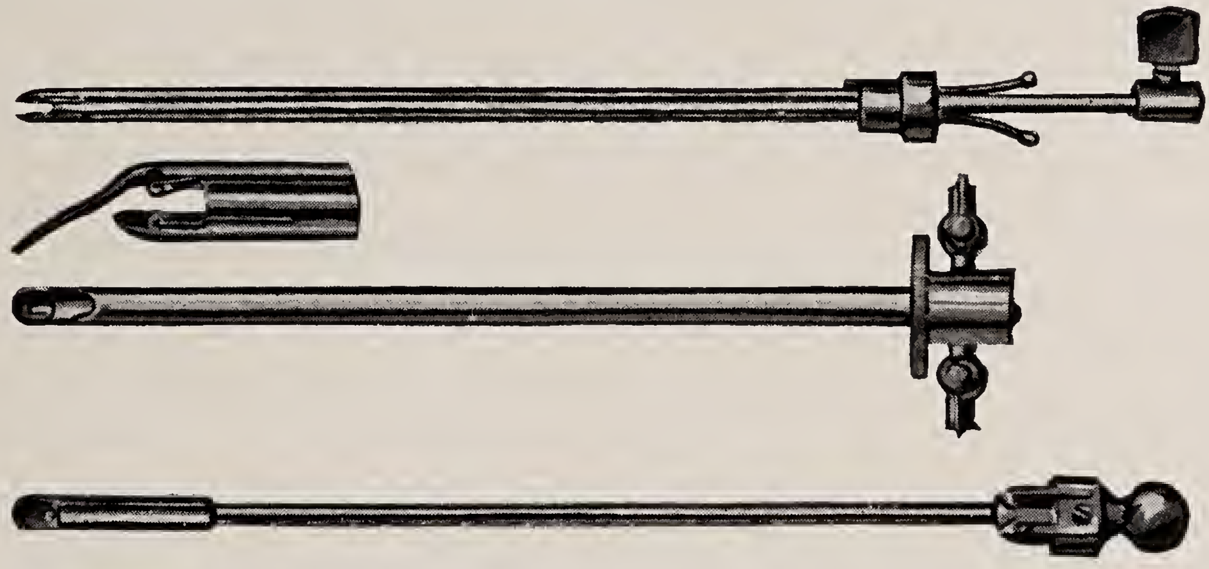

Fig. 9. The McCarthy Ejaculatory Duct Catheterizing Instrument.

For such procedures as catheterization of the ejaculatory ducts, injection of the sinus pocularis, and fulguration of papillomata and granulations of the prostatic urethra, internal meatus and veru, and of the hypertrophied veru itself, the McCarthy panendoscope, or the Lowsley urethroscope are the instruments of choice, though the Buerger, McCarthy, or Luys cysto-urethroscope are quite serviceable; also the removal of pieces of papilloma or exuberant granulations for microscopical examination by means of a snare or the punch forceps. For catheterizing the ejaculatory ducts a #4 ureteral catheter through the McCarthy ejaculatory duct catheterizing instrument or the metal catheter of Delzell or Young may be used. The author prefers the McCarthy instrument. Buerger says paralytic conditions of the internal sphincter may be suspected when there is lessened resistance to the entrance of the cysto-urethroscope, and by the relaxed condition of the sphincter as indicated by the greater freedom of motion in the urethra, and by the absence of bleeding when the instrument is pushed back and forth.

EXCRETION UROGRAPHY

This is the method of obtaining urograms by the excretion in the urine of an iodide solution that is usually given intravenously. It marks another great advance in diagnostic urology. It was first attempted by Rountree and his co-workers at the Mayo Clinic, in 1923. They used sodium iodide 10 per cent., intravenously and orally, but met with little success. Later Roseno, in Germany, using sodium iodide and urea intravenously, made the first practical excretion urograms. His solution did not meet with favor on account of the reactions and unsatisfactory pyeloureterograms. In 1929, Binz, Von Lichtenberg and Swick perfected another iodide preparation, *uroselectan*, which gave satisfactory urograms when injected intravenously in 40 c.c. doses. Except for some nausea and vomiting, a sensation of warmth over the entire body and more or less pain in the arm during the injection, it was free from untoward symptoms. It is, therefore, due to the work of Binz, Von Lichtenberg and Swick, that excretion urography is now a practical diagnostic method of great clinical value. Several preparations for excretion urography are now on the market, viz., diodrast, skiodan and hippuran. There are some contra-indications to the use of all three. Diodrast, however, is by far the best preparation I have used. It is given in 20 c.c. doses, its only contraindication being that it is said to lower the blood pressure; consequently it should be used with caution in severe shock. It causes no pain when injected and I have never seen any reaction from it. As skiodan raises the blood pressure, it is contra-indicated in severe hypertention, arteriosclerosis and aneurism. It frequently causes great pain in the arm during the injection; however, this quickly subsides when it is completed. Excretion urography is a valuable aid but in no sense replaces retrograde pyelography. It possesses one great advantage, however, in that it can be used in cases where cystoscopy and retrograde urography are impossible and in children and adults when it is deemed inadvisable. Excretion urography should not be relied upon alone unless all clinical evidence corroborates its findings. It is of special value in visualizing a calculus that does not cast a shadow on the x-ray film. It may be used also to demonstrate kidney function but it is not always reliable. I have recently had a case of chronic bilateral pyelonephritis in which a good pyelogram of the right kidney and ureter was shown, and no shadow was obtained of the left pelvis or ureter in films made from 15 minutes to one and a half hours after the injection, and on retrograde catheterization and the intravenous administration of phenolsulphonephthalein the output from the left kidney was 15 per cent. in 15 minutes, while that from the right was only 10 per cent. Braasch states that complete failure of visualization of one side in repeated films must be interpreted as indicating renal dysfunction. He also states that intravenous urography should be used as a routine in the diagnosis of abdominal conditions, and that, when feasible, it is distinctly preferable to retrograde in the diagnosis of polycystic kidney, because it obviates the danger of infection which may follow retrograde urography. I would add that it also obviates the danger of instrumental anuria. Swick, 1933, reports that hippuran (sodium iodohippurate) may be given orally, and satisfactory urograms obtained. From 7 to 15 grams is dissolved in 75 c.c. simple syrup. No reactions were noted. The films are made at 45, 60, 90, 120 and 150 minutes with a moderate degree of compression. Beer and Theodore have recently reported on the use of neo-skiodan given subcutaneously. Two children and five adults were given 7 per cent. neo-skiodan solution (approximately isotonic), about 50 c.c. being injected into each axilla, a total of 7 grams. There is only the slight discomfort of hypodermoclysis. In no case did it cause subsequent tenderness or induration. The best urograms were obtained 50 to 60 minutes after injection.

Prof. G. Marion, 1934, states that intravenous urography sometimes gives too vague results and by not distending the pelvis, risks overlooking lesions which will be evidenced by the complete filling of the pelvis by retrograde urography. He further states that we must never rely on intravenous urography to estimate the functional value of a kidney. The visibility in the kidney of the substance injected intravenously depends not only on the manner in which the organ eliminates such a substance but also on the manner in which it is evacuated by the pelvis or retained in it. Often the better kidney seems to have the poorer elimination. (This was borne out in the author's case.)

In injuries to the urinary tract excretion urography stands supreme, but unfortunately in many injuries the blood pressure due to shock is so low the output of urine is so diminished it is often difficult to differentiate the shadow cast by the urine as it escapes from the torn kidney, ureter or bladder. In such cases skiodan theoretically should be used, as it raises the blood pressure, and hence should give better visualization of the escaping urine. This advantage is lessened, however, by the pain it causes while being injected. The author has seen no deleterious effects when diodrast has been given to patients following severe injuries to the urinary tract.

Serial pyelography is a newer method of obtaining more diagnostic data by taking several pyelo-ureterograms after the pyelographic medium has been injected into the ureteral catheters. By this means, conditions of the pelvis, calyces and ureters are frequently brought out that would not be suspected, and conditions that on one plate would suggest pathology are often shown to be perfectly normal.

Serial pyelo-ureterograms as an important aid in diagnosis has been recognized for some time. The investigations of Legueu, and, later, Cumming and Jarre, and the ingenious Jarre-Cinex camera were epoch-making. The Jarre-Cinex camera, however, was too expensive to permit of universal use. To T. D. Moore goes the credit of devising a simple, inexpensive and highly practical apparatus that can be fitted into the ordinary Bucky diaphragm. It permits the taking of a series of 3 pyelo-ureterograms on a single 14 by 17 film in a few seconds. With two cassets, six pyelo-ureterograms may be rapidly made on 2 standard size films.

Fluoroscopy of the kidneys and ureters while the pyelographic medium is being injected is often an aid in diagnosis. Serial pyelo-ureterograms, however, have practically eliminated the necessity of fluoroscopy in most cases.

OPERATIVE CYSTOSCOPY

These include all measures of operative, diagnostic or medicinal means that can be satisfactorily accomplished through the catheterizing and operating cystoscope.

The McCarthy panendoscope is the premier in this field, though the Lewis and Brown-Buerger are very satisfactory. Buerger says the Nitze and Kultner cystoscopes are employed abroad. For the removal of small stones and large pieces of papillomata and sessile growths, the Young rongeur cystoscope and Lowsley's are especially suitable. For the crushing of small stones, the Kretschmer modification of the Young rongeur is more satisfactory; but when the stone or stones are large, the lithotrite, with lens system attached, is the instrument for litholopaxy. Where more than two ureters are present or where Garceau or Woodruff catheters are used, it is possible to pass three catheters or two large ones easily through the operating instruments.

Operative procedures for assisting the passage of ureteral calculi. These consist of dilation by means of two or more catheters passed up the ureter. The endeavor is made to make a small catheter or catheters pass beyond the calculus, but, failing in this, we pass as many as are possible to the calculus and leave them in situ for 24 to 48 hours. Injecting olive or gomonol oil 2 or 3 times a day may also help. Separation of the stone from the ureteral wall by the Livermore stone dislodger, followed by dilatation and an indwelling catheter, has given excellent results in my hands. Before passing the catheters, the Walther dilator, with increasing size bulbs, may be passed to dilate the ureter below the stone. When the ureter has been dilated to #11 F, the Livermore dilator may be passed, and when the stone is reached it is expanded and withdrawn, thus dilating the ureter as high as #17 F.

It is preferable to get a catheter beyond the stone if possible, as this promotes drainage and prevents back pressure and damage to the kidney.

In cystoscopic manipulations of ureteral calculi, it is essential to test the kidney function at frequent intervals, for if the function begins to fail it is imperative to remove the stone by operation rather than subject the patient to possible destruction and loss of the kidney.

Buerger recommends the introduction of graduated metal olives at the end of an electrode, through which the D'Arsoval current may be applied. Beginning with a #5 or #6 F olive, it is passed up the ureter to the calculus, and with the indifferent electrode over the lower abdomen, and the current of 200 to 400 milliamperes turned on, gentle pressure is brought to bear on the electrode. Often the obstruction gives way after a few seconds and the electrode is removed and a larger bulb screwed in. (Cabot's Urology, 1924.)

Although I have advocated the use of the D'Arsoval current for a few seconds for the reduction of edema in the ureter to promote the passage of ureteral calculi, I believe the repeated use of bulbs and this current is a dangerous procedure and one quite capable of producing damage to the ureteral wall with resulting ulceration and extravasation of urine.

When the calculus is near the ureteral orifice and there is marked edema and swelling, the high frequency current is a valuable aid in reducing the edema and assisting the entrance of the stone into the bladder. Meatotomy, too, of the ureteral orifice is also necessary at times before the stone will pass and this may be done best with the Bumpus scissors or with Moore's meatotomy electrode, the advantage of the latter being the absence of hemorrhage, which may be severe when the scissors are used. Should it occur, fulguration will usually check it, though it may be difficult to see the bleeding point. With the McCarthy panendoscope, however, it may be successfully accomplished. Bleeding may be prevented, according to Buerger, by a preliminary linear burn by fulguration along the line of incision. Intra-urethral manipulation is a delicate procedure and must be done with the utmost care and gentleness to avoid injury to the ureter, a urinary fistula, peritonitis and death.

The removal of pieces of tissue for microscopical examination. This is a justifiable procedure and should be done in every case where we suspect malignancy and that does not show improvement after fulguration, or where the growth has recurred after having been destroyed. Other diseases, such as tuberculosis or syphilis may be diagnosed or at least suspected by this means. Pieces of papillomata may be snared off, or pieces of sessile tumors may be grasped with small cystoscopic forceps, or, better, bitten off with the Lowsley, Kirwin or Young rongeur instruments.

After removal of pieces of growths, it is best to fulgurate both on account of hemorrhage and the possibility of the spread of the growth.

The removal of foreign bodies and encrustations. Foreign bodies such as catheters, hair-pins, chewing gum, et cetera, may be removed very satisfactorily with the Young, Kirwin, or Lowsley rongeur instruments. They may also be removed (if possible to grasp them) with the cystoscopic forceps through the Brown-Buerger operating cystoscope or the McCarthy panendoscope.

For the removal of encrustations, the injection of acidophilous bacillus is so satisfactory I see no reason to subject the patient to cystoscopic manipulations.

Stones in the bladder may be crushed with the Ravich or Kirwin lithotrite. If small and not too hard, they may be crushed with the Kretschmer, Kirwin or Young rongeur.

BLADDER ULCERS

Bladder ulcers may be fulgurated or cleaned up by the punch forceps or a small curette. Should hemorrhage occur, it may be controlled by fulguration.

Ureterocele, cystitis, and cysts about the ureteral orifices may be treated by fulguration or incision with the cystoscopic scissors or a special cystoscopic knife.

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SURGERY OF THE URETER

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INTRODUCTION

Devotion of space to ureter surgery as such is a mark of distinction only recently won. The importance assumed by this link of the urinary chain in the past ten years is dramatic in its development. Much is yet to come. New drugs, instrumental refinements, ureter-consciousness in the profession, all unite to insure an increasing respect and an eagerness to know the full rôle of the ureter in the economy of the body.

The amount of experimental work on the ureter in our own country and abroad has been prodigious. Much of it cannot yet be properly evaluated nor clinically applied. It is the hope of presenting a wholly usable surgery, rather than any lack of appreciation, which leads us to omit a very large volume of this work in our discussion. A full bibliography will be found at the chapter's end.

EMBRYOLOGY OF THE URETER

In few structures does human embryology present more interesting developments than in the ureter. The frequency with which anomalies of the upper urinary tract are encountered clinically increases the practical importance of this subject.

Developmental irregularities are not explicable in their entirety. The intimacy of the primitive genital and excretory organs should be emphasized. Anomalies of termination are the most readily understood because of the unity of these embryonic structures. The reader will benefit from a supplementary study of genital, bladder, and kidney development.

The earliest urogenic structure, the *pronephros,* is first seen at the 2–3 mm. stage, the first month of embryonic life. The pronephric tubules arise as a series of projections from the primitive lower cervical and upper dorsal segments in the outer portion of the intermediate cell mass. The pronephric duct, formed by the fusion of these processes, appears as a solid cord from the outer aspect of the intermediate cell mass, becomes canalized gradually, and pushes between the mesoderm and ectoderm to reach the tail of the embryo. Some time during the 4–6 mm. stage it turns on itself to empty into the cloaca.

The pronephric tubules do not degenerate until a second set of primitive urinary organs, the *mesonephros,* is well under way. There are two of these organs, each supplied with a duct. Beginning about where the pronephros ceases in its growth, this structure appears first in 3–4 mm. embryos as a series of tubules from the mesonephric ridge. They proliferate by branching until a relatively huge structure is formed. Laterally the mesonephric duct bounds the mesonephros. Mesially the developing genital ridge is seen. Maximum growth is attained about the sixth week and rapid degeneration follows. After the fourth month only its permanently functioning rudiments may be found.

The function of the degenerating mesonephros is assumed gradually by the developing *metanephros*. This structure begins in the fourth week as an evagination from the posterior surface of the mesonephric duct just above the angle formed by it with the cloaca. Its earliest development brings it into relation with the mesenchyme, which it pushes before it in subsequent growth. The ureter is destined to form from this mesonephric duct outgrowth. The mesenchymal cap, to which it becomes attached, adapts itself to the contour of the stalk's terminal bifurcation to become the renal structure. There begins at once a migration of the developing urinary structure to the vertebral column. Its antero-posterior plane in front of the vertebral column having been reached, a turning in the cranial direction is noted. Passing between the mesonephros and the vertebral column, the developing renal structure and the upper end of its stalk, the ureter, come to lie under the last ribs. The polar axis of the kidney, having formed a right angle with the main axis of the ureter during the cranial migration, now rotates gradually until it parallels the ureter.

ANATOMY OF THE URETER

In the appraisal of the ureter's part in the several syndromes with which we are now familiar, relation to other more maturely studied sources of disease is of vital importance.

Size, General Course, and Relations. At the level of the spinous process of the first lumbar vertebra the ureters leave the kidney pelves, slightly flattened, cylindrical tubes connecting the lumina of the renal pelves and the bladder. Their average length is 30 cm., their mean diameter 4 mm., and their walls approximately 1–2 mm. thick. As they course obliquely downward and inward behind the peritoneum, their caliber is slightly narrowed at the uretero-pelvic junction and at the pelvic brim. Anatomic narrowing occurs also at the uretero-vesical junction and at the ureteral orifice. In the female there may be narrowing at the level of crossing over the iliac vessels and through the broad ligament. Spindle-like, relative enlargements appear between these points of narrowing.

In the bony pelvis the ureters pass downward, inward, and forward to the uretero-vesical junction and obliquely through the bladder to end at the ureteral orifices in the bladder.

Relation of Ureters to Each Other. The two upper ureters are separated by a distance of 7.5 cm. This distance is constantly lessened in their downward course. A slight mesial direction diminishes it to 5 cm. at the sacro-iliac level and 3.2 cm. At the uretero-vesical junction the ureteral orifices are only 2.0 cm. apart.

Right Ureter in the Male. The right ureter runs mesially downward, fronted by the descending portion of the duodenum. It is crossed by the right colic and ileo-colic vessels. To the left is the inferior vena cava. Posteriorly lie the psoas muscle, fascia, and the genito-crural nerve. It crosses the iliac artery, passes behind the appendix, over the sacro-iliac synchrondrosis and obturator internus muscle, to turn inward behind the vas deferens and reach the base of the bladder. At this level the upper end of the right seminal vesicle is just behind it.

Right Ureter in the Female. In the female the lower portion of the right ureter passes behind and for a short distance parallel with the uterine artery, below the obliterated hypogastric artery, to and on the lateral aspect of the cervix uteri to reach the base of the bladder.

The Left Ureter. The left ureter differs from the right only in that it is related to the abdominal aorta and its bifurcation.

The Terminal Ureter. After entering the bladder, the ureters pass obliquely for about three-fourths of an inch to terminate in the ureteral orifices at the lateral extremities of the trigonum vesicæ. The terminal one-half inch is just subjacent to the vesical mucosa. By this proximity distention of the bladder produces hydrostatic closure of the uretero-vesical orifices. Of further assistance in the maintenance of valve action is the contraction of the trigonal muscle at the time of micturition.

STRUCTURE OF THE URETER

The ureter is made up of an inner mucosal, a middle muscular, and an outer fibrous coat. The mucosa, of transitional epithelium, is continuous with that of the bladder and, like it, tends to relax in folds when not distended. The muscular coat is distinctly divided into an inner longitudinal, a middle circular, and an outer longitudinal layer. The external longitudinal layer is found with difficulty above the middle third. The importance of this group is questionable. The middle circular layer is more prominent in the upper third but constitutes the best-developed ureter musculature. The inner longitudinal layer is most prominent near the bladder. It is this poorly developed longitudinal muscular structure which makes the greatest gross difference between the structure of the bowel and the ureter.

The outer fibrous tunic constitutes a protective envelope of fairly uniform thickness. It is continuous with a like covering of the renal capsule above and the fibrous bladder coat below. The blood, lymph, and nerve supply is contained within this sheath.

Blood and Lymph Supply. The vascular needs of the ureter are met by the renal, spermatic or ovarian, internal-iliac, inferior vesical arteries and veins. Beneath the fibrous coat in which they terminate, minute branches penetrate to the muscularis and mucosa, anastomosing freely and literally surrounding the ureter with their capillary network.

The lymphatics accompany the blood vessels, empty into the pelvic and lumbar chains, which drain ultimately into the receptaculum chyli.

Nerve Supply. The renal, spermatic or ovarian, and hypogastric plexuses supply the upper, middle, and lower ureter respectively. Experimental data seem to show that fibers from the third, fourth, and fifth lumbar segments supply sympathetic innervation, while the parasympathetic fibers arise from the first, second, and third sacral segments.

End organs as such have not been satisfactorily demonstrated. Ganglion cells, however, are scattered throughout the fibrous layer, in greatest number at the renal end of the ureter.

Terminating in the fibrous layer, minute ramifications of the fibers perforate and penetrate the muscularis, which is elaborately supplied before termination in the mucosa.

The presence of an intrinsic innervation, adequate to permit peristalsis in the excised ureter, in no serious way contradicts the controlling function of the central nervous system over this viscus.

Résumé. The proximity of the ureter to duodenum and bowel, with which it is reciprocally innervated, should be emphasized. Relation to appendix, vas deferens, cervix uteri, and sacro-iliac joint must be borne constantly in mind if the obscure manifestations of ureteral disturbances are to be recognized.

PHYSIOLOGY OF THE URETER

The ureter is a one-way, automatic, self-adjusting urinary transit tube with two main functions: conduction of urine and protection of renal secretion. Its interposition between a secretory organ whose optimum function is maintained only with zero intra-pelvic pressure, and a reservoir whose pressure varies normally from 10–15 mm. of mercury, confers a versatility on this viscus not found elsewhere in the body.

Consider the amount of ureteral energy required to conduct the urine from kidneys to bladder in a fluid intake of 4000 cc. daily with that essential in the more average 800 cc. The efficiency with which these extremes are accommodated is creating belated general interest in a structure whose function until recently was regarded as passive.

Conduction. The function of the ureter most known is the conduction of urine from kidneys to bladder. The peristalsis by which this is accomplished resembles in most ways that which actuates the gastro-intestinal tract. Taking their origin in the pelvis of the kidney, waves of contraction, preceded and followed by annular dilatations of the ureter, descend bladderward with a frequency dependent upon the rate of urinary secretion. Their velocity gradually diminishes as they approach the bladder. The frequency and force vary with the conditions imposed. From above, the rate of secretion determines the frequency of peristalsis. Presumably the elimination of irritants also stimulates greater frequency.

The force of peristalsis is largely dependent upon the state of vesical pressure. Pressure is increased in the presence of any type of obstruction to outflow in the ureter or bladder.

Tone. The mechanism on which peristalsis is largely dependent for its regulation is the neuro-muscular equilibrium in which the ureter is held by its several elements. While early experimental data tend to establish an intrinsic innervation capable of stimulating peristalsis, the response of the ureter to known sympathetic and parasympathetic stimulants seems to make it conform to the regular pattern of central nervous regulation. The circular and longitudinal musculature, complementally innervated by constrictor and inhibitory fibers, makes possible the phenomenon of tone. In the ureter, as in other hollow, muscular viscera, dilatation is relative. The musculature is in a constant tonic contraction varying only in its intensity. Slight relaxation appears as dilatation when contrasted with the normal tonic contraction. This has been compared with the systolic and diastolic phases of cardiac activity.

The Protective Function. This function should be stressed more energetically. The mechanism by which it is accomplished is hydrostatic and peristaltic. Regurgitation of urine through the normal uretero-vesical valve seldom occurs. When such an accident does occur, there is not sufficient force behind the regurgitated urine to stem the peristaltic tide from above, and nothing comes of it. In the experimental establishment of valvular efficiency, distention has been carried to the point of rupture of the bladder without demonstrable reflux.

PATHOLOGY OF THE URETER

Just as the physiology and anatomy of the ureter are descriptive of its function and structure respectively in health, so should the pathology of this viscus describe its function and structure in disease. There may be some question as to the authenticity of any description of function in disease because of the paucity of post-operative and morgue material. Some of the functional disorders of to-day, however, will be structural disorders in the near future. A brief discussion can only sharpen the scrutiny to which these conditions are now subject and possibly stimulate interest in their more satisfactory classification.

Functional Pathology of the ureter may be defined as that group of changes in the behavior of the ureter for which no anatomic cause has been found. By definition, this small but important group is destined to grow even smaller with improvements in our methods of examination. Until such refinements are forthcoming, there seems to be a need for some loose classification and description.

These considerations, largely theoretical, are presented in the interest of further investigation. All functional disturbances of the ureter are related to peristalsis. The possible disturbances to which they may give origin are therefore limited by the extremes of tone.

Etiologically, nerve lesions of central and peripheral location play an important rôle. These may be toxic, inflammatory, or mechanical, irritative, complete or partial destruction. Muscular lesions of the ureter may be due to local or focal infection, to intra- or extra-ureteral pressure or inflammation. We have as yet only a gross, crude scale by which the approximate end results of these various processes may be appraised. Stricture formation, hydronephrosis, megalo-ureter all have as their origin some one or more of these conditions.

There are many able observers who demand that changes be demonstrable by gross or microscopic post-mortem study before they be given clinical recognition. The majority of surgeons now admit as entities spasm and stricture of the ureter. Most will concede the rôle of kink and torsion in a certain type of patient. But few realize the functional potentialities and our inadequacy to detect them in their incipiency.

Hypertonicity. The syndrome of frequent urination, back pain which may be severe but without urinary findings, obstruction to large caliber ureteral bulb, or urographic evidence of change, is not uncommon. Sometimes ureteral spasm is noted at the time of cystoscopy or during pyelo-ureterography. Relief may follow the manipulations incidental to examination. The condition may be uninfluenced by catheterization or may be temporarily aggravated by it. Re-examination several months later demonstrates, not infrequently, mild renal or ureteral lesions.

This really definite colic, without demonstrable cause, has been recorded frequently enough to merit inclusion in a list of functional disturbances of the ureter. Not always is the course so severe. Often it appears as a vague distress in the back, usually though not always lateralized, associated with irregular frequency of urination, usually diurnal rather than nocturnal in appearance. The pre-cystoscopic picture is not unlike that of ureteral stricture. The entire absence of urinary findings postpones cystoscopy and urography in many cases.

Hypotonicity. This extreme of ureteral activity is less definitely grounded in clinical experience. It is typified by the slightly relaxed ureter and mild hydronephrosis when examination of the ureter, bladder, and urethra fails to reveal obstruction. The assumption is that the ureteral tone is poor. Peristalsis proceeds at a slower pace and with lessened intensity. The effect of ureteral instrumentation is neither diagnostic nor of benefit to the patient in this disorder.

It is only at the extremes of tone and activity that we may even suspect these ureteral conditions. We realize our inadequacy more acutely here than anywhere else in the urinary tract.

STRUCTURAL PATHOLOGY

Organic changes of the ureter lend themselves poorly to general description. The following classification will be used in their discussion: (*a*) Anomalies, (*b*) Injuries, (*c*) Simple inflammation and obstruction, (*d*) Vesico-ureteral reflux, (*e*) Calculus, (*f*) Tuberculosis, (*g*) Syphilis and neurogenic disorders, (*h*) Bilharzia, (*i*) Ureteritis Cystica, (*j*) Leucoplakia, (*k*) Neoplasm.

ANOMALIES OF THE URETER

Anomalies of the ureter have achieved surgical importance only since the perfection of urographic methods. While autopsies continue to disclose anomalies which were not recognized clinically, uretero-pyelographic study is a source of ever-increasing fertility. The frequency and degree to which anomalous ureters and kidneys are subject to inflammatory and neoplastic change necessitates their careful description.

The most practical classification suggested to date is as follows:

(1) Anomalies of Number
(2) Anomalies of Caliber and Form
(3) Anomalies of Origin
(4) Anomalies of Termination
(5) Diverticula

Anomalies of length were not included for the reason that they are solely dependent upon renal position.

(1) Anomalies of Number

The limits of variation in number are fixed rather definitely. They vary from complete absence to complete reduplication bilaterally. A rare occurrence of more than two ureters to the same kidney has been reported. For purposes of exposition, consider the possibilities on one side only, it being understood that any variation occurring on one side may be present on both sides simultaneously.

The partial and complete duplications are the most observed ureteral anomalies. The ureter may divide at the pelvis and a T-shaped projection continue upward to form a bifid pelvis, the simplest and perhaps most common of all ureteral anomalies. If the bifurcation occurs below the level of the pelvis, its pyelographic appearance is more graphic. It is seen that such a division may occur anywhere between the kidney pelvis and the bladder. As long as one ureter is manifestly an off-shoot from the other, and they share an orifice in the bladder, the anomaly is known as bifid ureter. Two complete ureters with separate orifices in the bladder are described as completely reduplicated. Bifurcation of the ureter from above downward does not occur. Total absence of both ureters and kidneys is one of the rarest of conditions. Solitary ureter and bilateral reduplication occur not uncommonly. Since only those which develop symptoms or come to post-mortem may be recognized, the number reported is small. Bifurcation of the ureter at varying levels is often seen in conjunction with reduplication on the opposite side. Alone, it occurs frequently enough to make it commonplace.

Diagnosis is based upon cystoscopic and pyelo-ureterographic evidence. Bifid ureters were quite rare occurrences, even after introduction of the pyelographic method, until interest in the ureter led cystoscopists to withdraw the ureteral catheter while injecting the pelvis, thus portraying the unsplinted ureter and any branching present.

Treatment of this type of anomaly *per se* is infrequently required. Bifidity of the pelvis or upper third of the ureter is a rare source of trouble. Infections in kidneys drained by such ureters are treated very much as infections in normal kidneys except that dilatation of the branch ureter and irrigation of its pelvis is usually impractical. Operative drainage or removal is accordingly more frequently required.

In the lower two-thirds of the ureter bifidity is also productive of symptoms. Here again, for infections, dilatation is usually impractical,

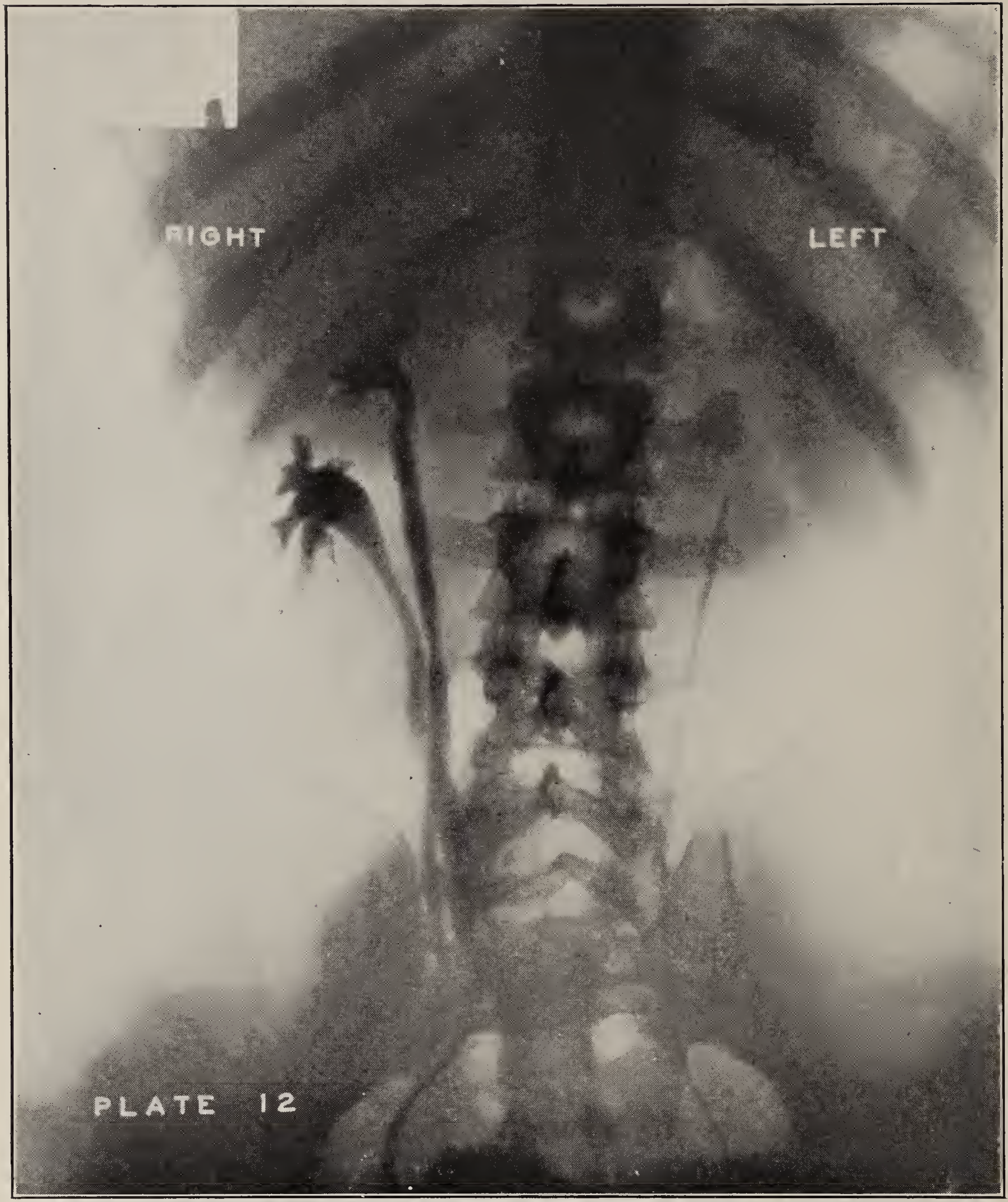


Fig. 1. Anomalous right ureters. This shows bifurcation of the ureter in its lower third and crossing of the two ureters near the junction of the middle and upper third. Note the rather normal lower and T-shaped upper pyelograms.

and surgical drainage or removal of inadequately drained renal tissue is required more frequently than in similar infections in the normal kidney. Completely reduplicated ureter and pelvis gives rise to symptoms because

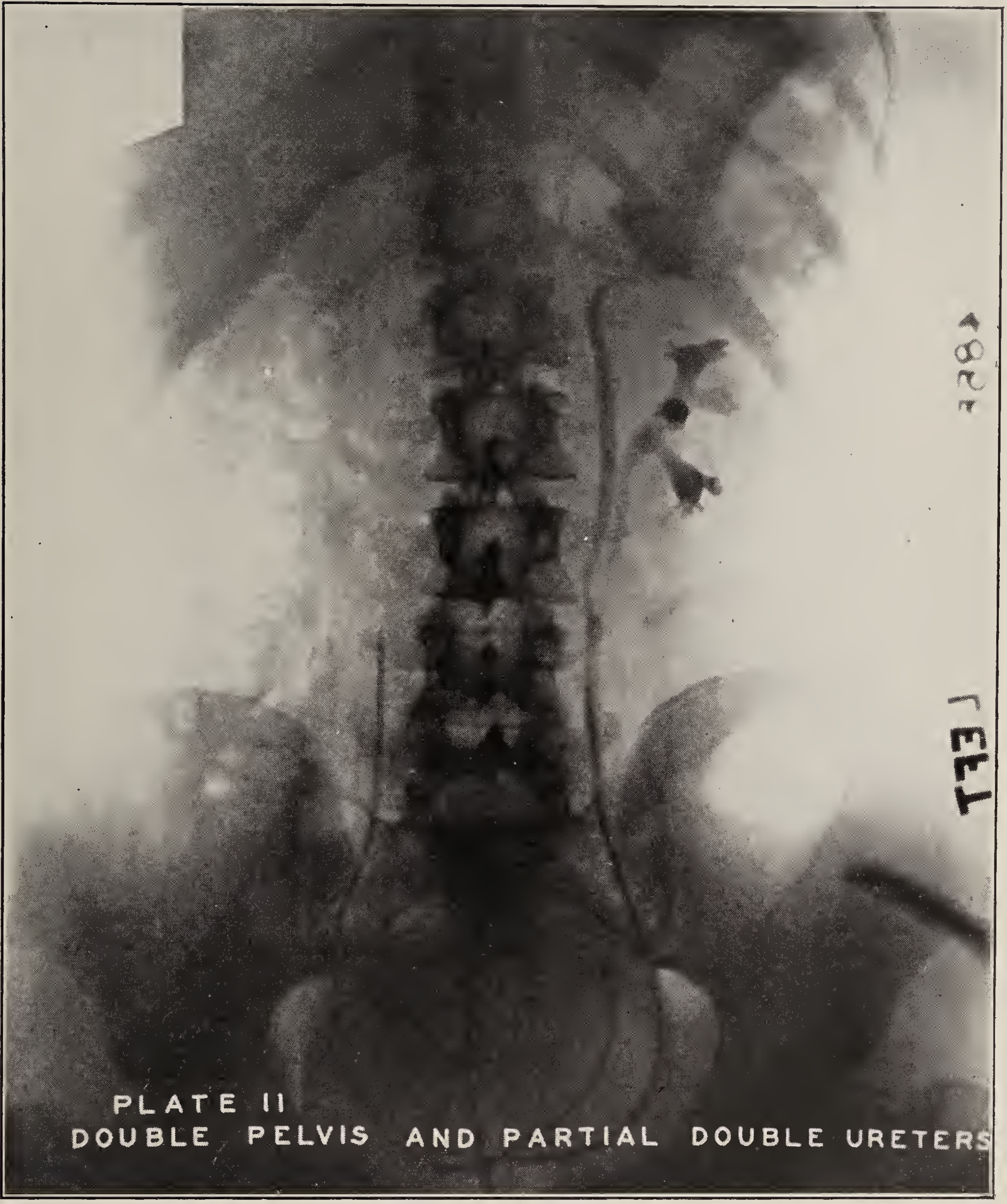


FIG. 2. This shows bifurcation of the middle ureter by withdrawing the ureteral catheter just below the site of division. Again the T-shape of the upper pyelogram is shown.

of obstruction occasionally caused by crossing of the upper ureter over its fellow. Ureteral dilatation and kidney pelvic lavage usually suffice in these infections.

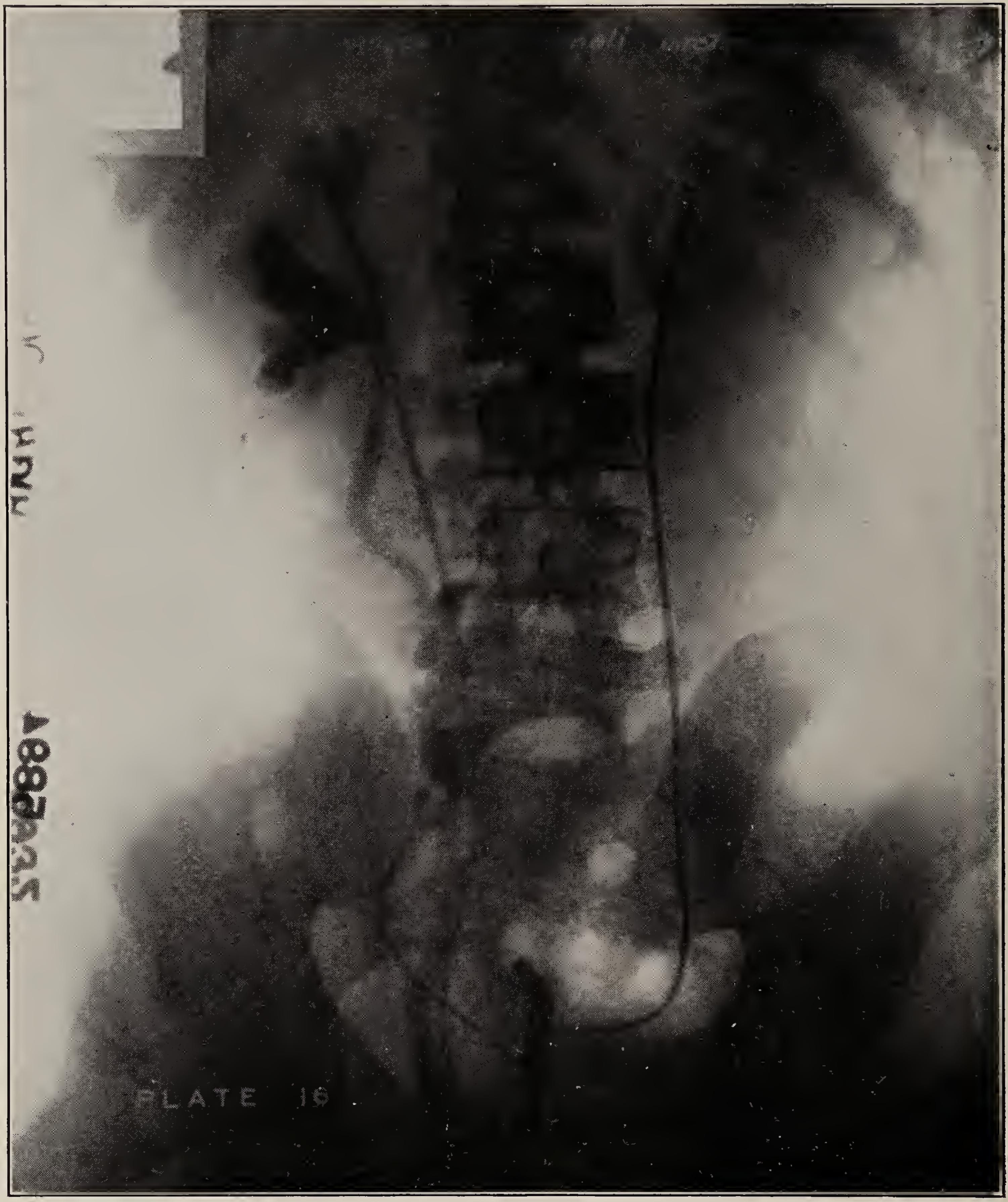


FIG. 3. Another example of bifurcation of the ureter in its lower third. There is definite pyelectisis and dilatation of the calyces shown in the lower pyelogram, with some distortion and dilatation of the ureter.

In duplications and low bifidity, the functional capacity of the poorly drained unit may warrant anastomosing the affected ureter to its unobstructed fellow. Hemi-nephrectomy may be carried out should a surgical condition arise which involves only one functional unit of the double kidney and ureter.

(2) Anomalies of Caliber

These anomalies take two forms: narrowing and dilatation.

Congenital Narrowing of the ureter is a common variation. The finding of such narrowings in the ureters of young infants post-mortem, associated with hydronephrosis, has been widely noted. Whether such narrowings persist commonly through adolescence is controversial. Certain it is that since ureteral catheterization has been made available to infants and young children, a large clinical experience has accumulated. The levels at which narrowings occur coincide in general with those at which we expect to find the ureter smallest. There may be several such in the same ureter with dilatation above. Hydronephrosis is the rule, although only the ureter may be dilated.

Diagnosis of congenital narrowing of the ureter is based upon a history of occurrence usually in the very young, urinary frequency or incontinence, with or without abdominal pain and mass which disappears after voiding large quantities of urine.

Cystoscopic study usually reveals a definite impairment of function on the affected side. The narrowing or narrowings may be detected by the ureteral bulb, and their presence made a matter of record by the uretero-pyelogram.

Treatment of congenital narrowing is usually conservative. Dilatation of the ureter by intermittent catheterization is adequate in mild cases. Superimposed infection on the hydronephrotic kidney necessitates an indwelling ureteral catheter or catheters of sufficient size to permit satisfactory drainage. These catheters are left *in situ* until the function of the kidney returns, the urine clears, and the condition of the patient improves. The after-care consists in maintaining dilatation.

In those cases in which one cannot dilate from below, plastic procedures are indicated, if the function of the kidney warrants.

Congenital Dilatation. This anomaly has been a surgical enigma since its recognition. It is often bilateral. The widening of a segment or of the entire ureter, sometimes to the size of the bowel, occasionally with no demonstrable mechanical obstruction, has led to much discussion. Usually one finds strictured ureter orifice, posterior urethral valves, or other obstruction to explain this phenomenon. In the absence of demonstrable

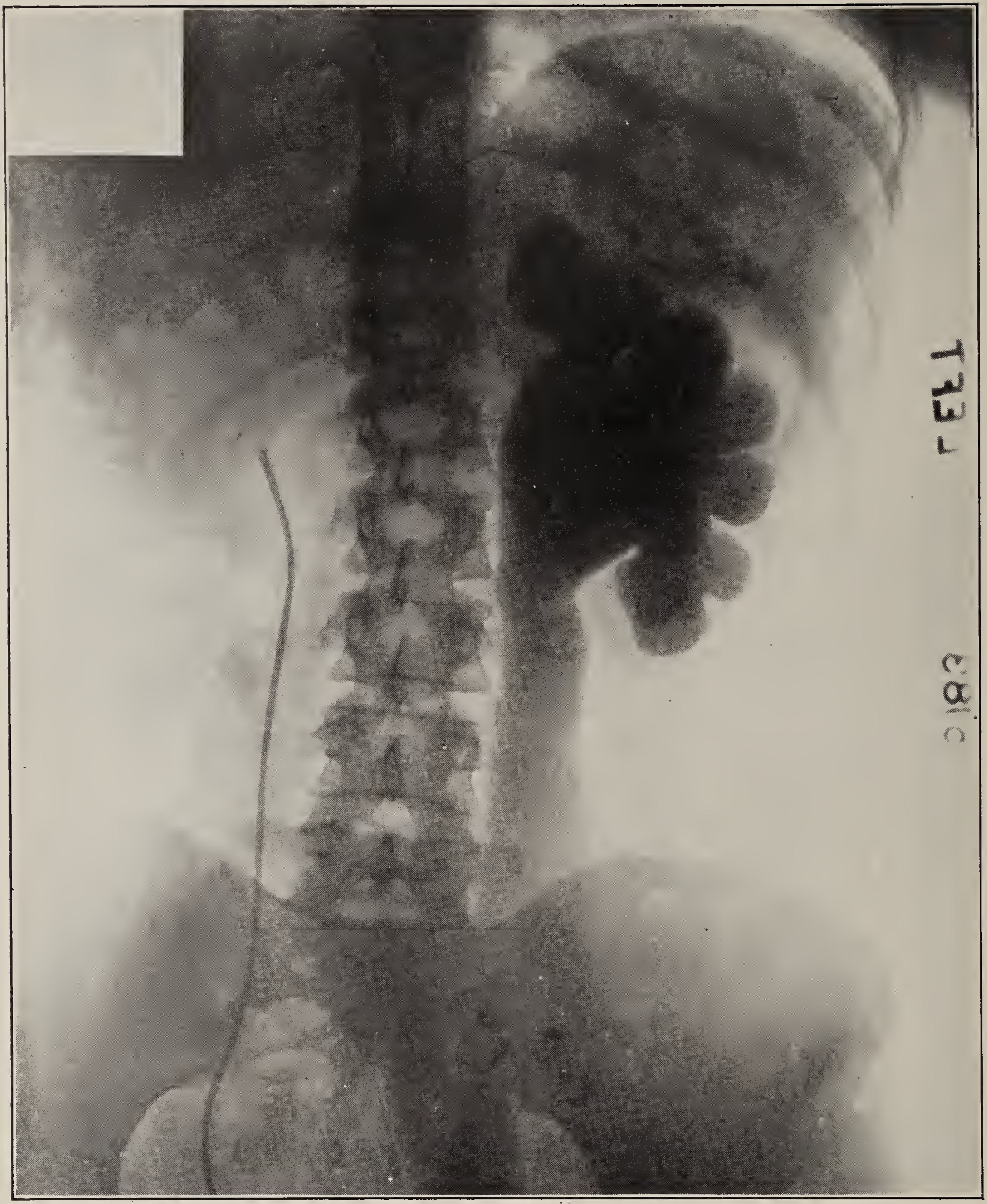


FIG. 4 shows megeloureter. There is massive dilatation of the pelvis, calyces, and ureter. No point of obstruction at the uretero-pelvic junction was found.

obstruction, the theoretical basis is relaxation of a part or the whole of the ureter from nerve lesion or from a congenital absence of muscle tone.

Spindle-shaped enlargements, usually between narrowings of the ureter, have been described. The terms "total" and "subtotal" have been used to distinguish, respectively, between dilatations in which the entire ureter shares and those in which all but the ureteral orifice partakes.

Diagnosis of congenital dilatation is suggested by a history of renal distress whenever the bladder becomes distended. It is seen at all ages, but usually in childhood. There may be a record of difficulty in urination.

Cystoscopic study is completely informative. The vesical fundus may be trabeculated as extensively in young children as in elderly prostatics. Valves at the outlet or in the urethra are occasionally seen. The ureteral orifices, if affected, may be so dilated that the end of the cystoscope may be introduced readily, resembling diverticula.

Uretero-pyelography usually results in a cystogram, unless the patient's head is lowered enough to prevent the opaque substance from pouring into the bladder. Accordingly, the best method to obtain urograms, in the type with patent ureter orifices, is cystography. This reveals the bladder, ureters, and kidneys as one continuous cavity.

In the partial and subtotal forms, urography is best carried out with a catheter sufficiently large to occlude the orifice.

Treatment is of little value. Transplantation into the bowel offers the only hope unless there is a removable obstruction at the vesical outlet or in the urethra.

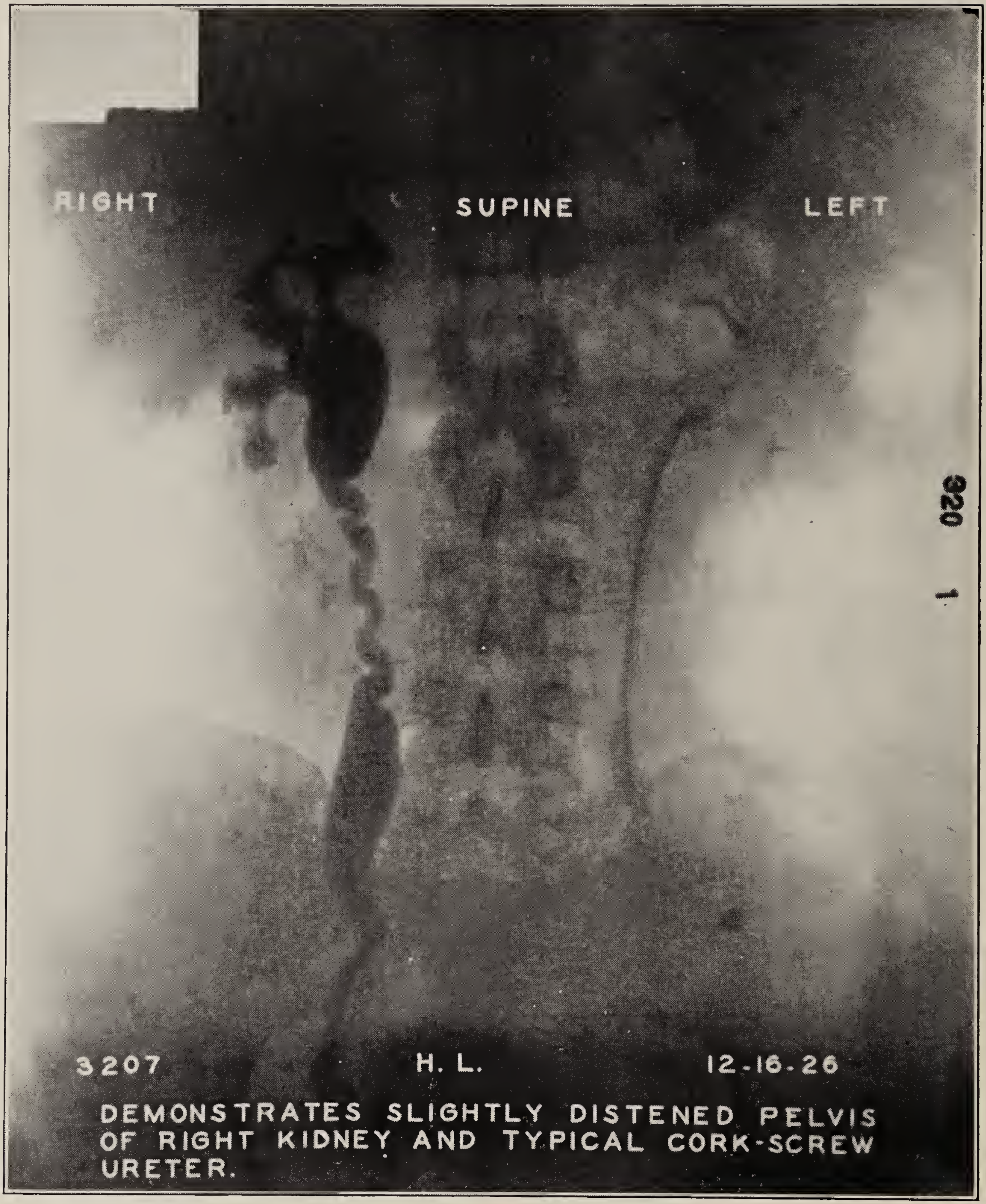
(3) Anomalies in Form

Anamolies in form include valves, spiral twists, and kinks.

Valves are found usually in the ureters of the new-born. They have been reported uncommonly, usually as autopsy findings. Either end of the ureter may be the site of the formation, the result of which is hydronephrosis and renal failure. No form of treatment has been available because of the untimely recognition of the disorder. Implantation into the bowel would seem to offer the only hope. So frequently is the condition associated with inherent frailty that there is little hope to be held out.

Spiral Twists of the ureter. These are fairly common in large clinics. The cork-screw appearance being so suggestive of chronic infection, a careful study of function and bacteriology of the kidneys is necessary to establish the congenital nature of the change. Often the characteristic urogram still leaves us in doubt on this point. The frequent association with infection explains the reluctance of observers to report them as congenital.

Treatment is necessary only when pain is a clinical, or hydronephrosis a urographic observation. Dilatation of the ureter and pelvic lavage are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DEMONSTRATES SLIGHTLY DISTENED PELVIS OF RIGHT KIDNEY AND TYPICAL CORK-SCREW URETER.

FIG. 5 shows the cork-screw ureter of non-tuberculous type. Note the spindle-shaped enlargement in the middle third. The clear division of the periphery of the ureter as well as the lack of change in the calyces denotes this as non-tuberculous. [This and many other pyeloureterograms were borrowed from the Department of Urology (James Buchanan Brady Foundation) of the New York Hospital, and the author wishes to express his thanks for their use.]

sufficient in many cases. Ureterolysis and nephropexy must be carried out if these measures fail.

Congenital Kinks of the ureter are usually found in the upper portion. They may be associated with unduly elongated ureter or nephroptosis. These again must be distinguished from kinks of post-operative or inflammatory origin.

Diagnosis of congenital kinks of the ureter is based upon a history of pain in the loin or abdomen occurring in the first two decades of life, frequently without urinary symptoms or signs. The findings at cystoscopy and urographic examination are usually diagnostic. The differentiation of the congenital from the acquired kink is usually possible by careful history taking. In the latter type, the distress may be definitely traced to a medical or surgical occasion, whereas in the former type the occurrence independent of such illnesses is indicative.

Treatment is frequently possible by elevation of the kidney with a well-fitting belt and dilatation of the ureter. Failing in this, ureterolysis and nephropexy must be performed.

Résumé. Anomalies of caliber and form constitute a large chapter of urinary surgery in children. Because they are seen only in the terminal stages, prognosis is usually grave. Obstructive changes, of which the cause is removable, are those in which surgery is available.

Prompt attention to urinary dysfunction, to abdominal masses associated with dysfunction, may be the means of bringing palliation to a certain few for whom there is no other hope. The older the child at the time of appearance of symptoms, the greater the hope, as survival connotes a general vigor capable of supporting measures aimed at relief.

(4) Anomalies of Origin

These are made up of highly inserted ureters, the resulting angle creating a pool in the pelvis only the overflow from which is carried out by the ureter. Menasse reports a case in which the ureter passed entirely around the pelvis before turning downward.

Diagnosis of this rare anomaly is of great didactic interest. The only possible methods are pyelography or exploration.

Treatment is always surgical.

(5) Anomalies of Termination

Anomalies of termination consist of ureterocele, blind ureteral endings, and ectopic endings.

Ureterocele may be defined as a cystic dilatation of that portion of the ureter just proximal to the ureteral orifice, partial occlusion of which is uniformly associated with it. Although in its early stages the dilatation is no bigger than one's little-finger end, it sometimes attains large proportions. Rarely it grows large enough to reach and prolapse through the urethra in the female.

Diagnosis is by inspection cystoscopically. The rhythmic protusion and retraction which occur with peristalsis and the emission of urine resemble no other vesical tumor.

Treatment of ureterocele in its early stages is simple ureteral meatotomy. The cystoscopic scissors accomplish this satisfactorily, but their use is occasionally followed by annoying hemorrhage. The radiotherm knife, used through the operating cystoscope to incise the roof of the cyst adequately to admit a large catheter, is the method of choice. Whatever method is utilized, the orifice must be dilated regularly until healing has occurred, and observed periodically thereafter. Large tumors must be resected and the ureter reimplanted.

Blind-ending Ureters occur in two forms, usually as an accompaniment of reduplicated ureters. In one form, the second ureter is rudimentary and ends blindly above only. In the other form, the second ureter ends blindly above and below. At times there is a hypoplastic half of the double kidney developed around a second ureter which ends blindly below. Blind endings, which have no orifice at either end, are only diagnosed at operation or autopsy.

Diagnosis of blind-ending upper ureter must be made by the absence of elimination, as shown cystoscopically, and by the attempt at pyelogram. The absence of urinary irrigation makes these ureters fertile soil for infection. Localizing symptoms, together with the ureterograms, may bring them to operation. Ordinarily they may be drained by catheterization at cystoscopy unless their size prevents. Their association with duplication probably causes them to be missed many times.

Treatment is cystoscopic when this is possible. Suppuration in a segment which cannot be reached cystoscopically requires open drainage.

Ectopic Ureteral Endings. This group of anomalies is interesting and unusual enough to have inspired an intelligent description. The most frequent example described is complete unilateral duplication with ectopic opening of the supernumerary ureter. Next in frequency is the single ureter with ectopic opening. Bilateral duplication of pelves and ureters with one ectopic opening completes the triad of uncommon ectopic endings. Most rarely unilaterally duplicated ureters end ectopically. The same rare incidence is reported of bilateral ectopia with bilateral duplication of the ureters.

Diagnosis of ectopic ureteral endings is based upon the history of urinary incontinence with normal bladder function, upon physical findings particularly in the female, and on cystoscopic and urographic examination. Because of the accessibility of the female genitalia to direct examination, and their separation normally from urinary function, many more cases are recognized in this sex. Urethral ureter in the male, if opening back of the external sphincter, may occasion no symptoms referable to the ureter. In the female, incontinence ensues more readily.

Physical examination of the female reveals a labial, vaginal, or periurethral aperture, through which minute catheters may be passed for study. The administration of indigo carmin facilitates this examination if the kidney served by this ureter is functional.

Cysto-urethroscopic study is diagnostic in the female if the opening is anterior to the sphincter. In the male an intra-urethral orifice may be recognized through the urethroscope, and catheterization accomplished with the aid of indigo carmin to complete the study.

Treatment is necessary whenever symptoms are produced. Reimplantation of the ureter is carried out if the kidney is sound. Otherwise, nephro-ureterectomy must be done.

(5) Diverticula

Diverticulum of the ureter is considered congenital by most observers. The budding evagination which characterizes this process is usually associated with no demonstrable obstruction upon which it might depend. The rarity with which it is reported rests upon freedom from symptoms. In the cases observed, its discovery was accidental in most instances, occurring during operation performed for other disorders or autopsy.

Diagnosis is made from ureterographic picture and at operation.

Treatment, when productive of symptoms, is surgical removal with transplantation if the lower end be involved.

INJURIES TO THE URETER

For obvious reasons the actual incidence of ureteral injury must be unknown. Greater enthusiasm in seeking improved methods, and a growing willingness on the part of operators to report their technical errors, will tend in time to provide a more accurate knowledge of the character and number of these interesting surgical problems.

It is estimated that obstetrical and gynecological surgery account for three-fourths of all ureteral injuries. The number of traumatic injuries is comparatively small.

Traumatic Injury. One cannot fail to be impressed with the security enjoyed by the ureter from external injury. Its unity with the peritoneum anteriorly renders it practically immune to penetrating, perforating, and crushing injuries which do not cause greater intra-abdominal havoc. It is in this relation, however, that one danger from injury lies. Because of the profound and critical illness which follows immediately upon such injury, the surgeon must devote such time and attention to the repair of intra-peritoneal viscera that concomitant ureteral damage is often overlooked.

Posteriorly, the dense dorsal musculature and, except for the short segment between the last rib and the ileum, bony barriers are interposed between the ureter and injury from without.

Bullet wounds, knife wounds, crushing and lacerating wounds are capable of producing a variety of injuries to the ureter. Simple contusion, laceration of the wall, partial or complete section may occur.

It is inconceivable that the simpler lesions should be recognized at the time of injury because of the minor immediate symptomatology. Presence of blood in the urine will suggest some urinary tract injury. The indications for abdominal surgery are usually so imperative that only passing thought is given this sign.

Development of fistula following injury may occur post-operatively through the abdominal wound of exploration. It may or may not be preceded by evidence of urinary extravasation. If the urine be uninfected, a mass in the flank on the injured side may be the first evidence of severed ureter. Evacuation of the fluid by incision confirms the diagnosis. Should the urine be infected, the picture is one of sepsis with mass formation, and, when accompanied by generalized peritonitis or shock, it may be overlooked until autopsy.

Treatment of traumatic injuries is surgical. Failure to restore an outlet for the kidney is a sentence to hydronephrosis. The indications depend upon the severity of the injury and the condition of the patient. Shock and infection, with or without bleeding, are not favorable conditions under which to do ureteroplasty.

If a torn ureter, from the upper fragment of which relatively blood-free urine is seen to escape, is encountered during exploration, it is the work of a moment to insert a large-size catheter to the kidney pelvis and draw the vesical segment over the other catheter end. The cut surfaces may be approximated rapidly enough to prolong the operation less than five minutes. The lower end of the catheter is left in the bladder. Five to eight days later it may be removed through the cystoscope.

If the injury is not noted at the time of operation, and the patient survives forty-eight to seventy-two hours, urinary fistula through the operative wound should be ignored until the patient's condition is stabilized and further surgery practicable. Should a mass develop in the flank, prompt drainage must be carried out and maintained until further operative procedure may be contemplated with safety.

Obstetrical Injuries are those occurring in prolonged labors and in instrumental deliveries, many of which are unavoidable. Avoidable or not, the immediately important consideration is recognition of the injury and institution of proper drainage for the affected kidneys as well as the extravasated urine when present.

Operative Injury is incidental to gynecological or obstetrical surgery usually. One rarely encounters it following extensive surgery upon the lower bowel for carcinoma. When one considers the intimate association between the cervix uteri, the uterine arteries, and the ureters, it is but natural that errors of judgment in the performance of hysterectomy, particularly per vaginam, are followed by occasional ureteral injury. It goes without saying that abortion is a fruitful source of injury.

How is one to know when the ureter has been injured? At the time an operation is taking place in a field shared by the ureter, this structure should be identified before and after clamps and ligatures have been applied. Some surgeons advocate routine installation of ureter catheters before the operation is started, as a preventive. When the operator is ready to close the wound, the anatomy is again reviewed and the condition of the ureter is noted. Obstetrical injuries can rarely be recognized at the time.

Post-operatively, ureteral section is followed by urinary fistula. Ligation of the ureter, if bilateral, is followed by immediate and permanent anuria. No other evidence may be available and none is needed. There may be a chill and persistent lumbar distress with or without fever. The general condition is unchanged by the injury for days. Cystoscopy, by demonstrating definite ureteral obstruction, establishes the diagnosis in doubtful cases.

Unilateral inclusion is suggested by persistent lumbar distress with or without oliguria. Occasionally anuria for eighteen to twenty-four hours follows operation, and then secretion is resumed perfectly normally. Under no circumstances should a longer period elapse without ureteral catheterization to establish the patency of the ureter or the lack thereof. Awaiting the cutting through or absorption of sutures applied to the ureter accidentally is a hopelessly vain procedure and should never be done.

Following difficult instrumental delivery or prolonged labor, the same principles apply. Anuria rarely occurs and, when present, is due to trauma. Suppression for more than twenty-four hours should warrant ureteral catheterization. The development of urinary fistula indicates cystoscopy as soon as this is safe, to differentiate vesical from ureteral injury. Urinary extravasation following obstetrical surgery, while rare, does occur, and should be handled, as extravasations elsewhere, by free and prompt drainage.

Treatment. Surgical injuries of the ureter resulting in uretero-abdominal fistulæ should be treated as soon as the patient's condition warrants. Extravasation should be drained and the resultant fistula closed by operation when this is practicable.

Complete bilateral ureteral inclusion by suture demands immediate surgery upon recognition. If cystoscopy shows occlusion, and the patient's general condition permits, ideal surgery consists in reopening the incision and re-establishing the ureteral lumena by freeing the ureter from above and ureteral catheterization retrograde, the catheters being removed cystoscopically several days later. It is indeed rare that the surgeon judges his patient competent to withstand this additional shock. Bilateral pyelostomy or nephrostomy, because it can be accomplished in a few minutes with little shock, is always the operation of choice under such circumstances. Usually, absorption of sutures permits re-establishment of ureteral drainage and spontaneous closure of nephrostomy or pyelostomy wound in twelve to eighteen days. When further surgery is tenable, cystoscopic study will establish patency of the ureters or the need for treatment. The abdomen may be reopened and ureteral continuity established by the plastic or drainage procedure offering the greatest hope of success, should this be indicated.

Should only one ureter be found occluded, the operator has the choice of sacrificing passively the affected kidney by ignoring it or nephrostomizing the patient.

Untreated Ureter Injuries are followed uniformly by stricture and hydronephrosis. It may require years to bring these sufferers to the surgeon. Many escape infection and cannot be accounted for. With the efficiency of our diagnostic methods, there would seem to be little excuse for the majority of sacrifices encountered.

Prognosis. The reluctance of surgeons to consider ureter damage in the post-operative complications of female genital surgery is being lessened by knowledge of its occurrence in the best hands. This one development presages a marked betterment of prognosis by bringing earlier drainage and more consistent effort to re-establish the function of the ureter.

Injury from Cystoscopic and Open Kidney Surgery. Perforations and lacerations of the ureter by catheter are most rare in our experience. They probably occur with greater frequency in clinics which utilize the direct, air-dilating cystoscopic instruments, although any instrument which permits the application of great force to ureteral catheter or bougie is subject to this criticism.

Perhaps we do not scrutinize our occasional severe reaction to catheterization closely enough. Possibly some patients get into other hands and such injuries are detected.

Diagnosis of ureteral catheter perforation is sometimes based upon failure to obtain urine through a patent catheter, and, if diagnostic ardor is not dampened by this evidence, attempts at pyelography result in extravasation of the dye. Profound reactions may follow instrumentation. It is probable that most of the injuries, being small, tend to heal spontaneously.

Treatment should include gentleness in instrumentation and cessation of attempts when suggestion of perforation is noted. If extravasation occurs, drainage must be instituted and the rent repaired.

During kidney operations the ureter may be torn. This occurs but rarely even in densely adherent structures upon which great traction must be made. The condition of the kidney and ureter, the functional capacity of its fellow kidney, the general condition of the patient, and the experience of the operator decide the wisdom of repair or nephrectomy. Usually the decision is for nephrectomy, because of the damaged condition of the kidney which necessitated the original operation.

Ureteral Fistula. Congenital termination of the ureter in the several genital and urinary cavities, as described under anomalies, may properly be termed fistulæ. In addition to the congenital, there are two other forms of ureteral fistula: those due to injury, which have been described under that heading, and those resulting from inflammatory adhesions of the ureter to other viscera.

The sources of such adhesions include, most often, tubo-ovarian, vas deferens and seminal vesicles, appendix, duodenum, and colon.

Internal genital processes, which rupture into the ureter, are most difficult of recognition. They may be suggested by an acute, painful, febrile genital infection relieved by the passage of large quantities of sanguino-purulent material from the urinary passages.

Bowel perforation into the ureter is a rare cause of fistula. The duodenum, by its proximity to the upper ureter and its susceptibility to ulcers that perforate, is occasionally guilty. Evidence is usually hidden by the emergency character of the intra-abdominal condition. Urinary frequency, back pain, blood, and duodenal contents in the urine may be expected.

The appendix, ascending and descending colon are near enough to involve the ureter in their ulcerative changes. Here again the perforating process, always an acute abdominal emergency, is complicated by urinary frequency, pain, and perhaps by air and feces in the urine.

Treatment of the primary pathology is more urgent than that attending the ureteral change. Failure to recognize the ureteral perforation at operation may lead to extravasation unless free drainage is provided. This may account for a small fraction of the morbidity and mortality incident to intestinal perforation.

Since the fistula is well walled off in the unoperated cases, permitting urine to escape only into the neighboring viscus, and free drainage is provided through the operative wound in those on whom laparotomy has been performed, there is rarely occasion for cystoscopic intervention during the height of the infection.

Complete urological survey should be carried out during the convalescence of every acute internal genital and every perforated intestinal lesion in which sudden urinary symptoms and signs have complicated the condition. By urography, the size and location of the fistula are demonstrated, the necessity for and the type of operative relief indicated.

In general, catheterization has a beneficent influence. The nature of the process sometimes precludes the passage of catheters beyond the fistula. In such cases one has no choice. If dilatation of the ureter can be carried out, a considerable proportion of cures will follow its use intermittently or by indwelling ureter catheter.

Open operation upon the ureter and the establishment of free drainage by pyelostomy or nephrostomy during the healing period of the repair constitute the approach to intractable fistulæ. The viscus from which ulceration began has frequently been repaired surgically. If such is not the case, closure must, of course, be carried out.

OBSTRUCTIONS AND SIMPLE INFLAMMATIONS OF THE URETER

The problem of obstruction is one of the most interesting and comprehensive in urinary surgery. Obstructions in the urethra and bladder, as well as those in and about the ureter, are of great importance.

Vesical Outlet Obstructions have been described in their relation to congenital changes in the ureter. Acquired obstructions of this type bear upon the ureter in two ways: by increasing intravesical tension, they proportionately add to the energy expended in conducting urine to the bladder; by producing muscular changes at the ureteral orifice, the competency of the uretero-vesical valve is so lessened that reflux of urine is permitted.

Both these changes represent phases of the same process, and will be described as one. Prostatism or stenosis of any portion of the urethral canal, by increasing the intravesical tension, provokes, in time, hypertrophy of the muscular portion of the ureter. Likening this to the first stage of cardiac valvular disease of the stenotic type simplifies the sequence. As long as the uretero-vesical valve is competent, fair kidney function is apt to be maintained. The length to which hypertrophy goes is well shown at post-mortem studies of prostatics whom intercurrent infections or vascular accidents have taken. Occasionally dilatation is seen in a part or the whole of the ureter with perfectly competent valve. Usually, however, regurgitation, and with it infection, have begun before decompensation begins. Pyelonephritis is the rule at this advanced stage. Its vesical origin and transmission through the incompetent ureter is unquestionable in most cases. Terminally, through the dilatation of the bladder, the ureteral orifice gapes, intravesical pressure becomes one with ureteral and renal pelvic pressure.

Vesico-renal Reflux occurs experimentally with the greatest rarity. In terminal obstructive changes it is common. In the great majority of outlet obstructions, which are unrelieved over a period of months to years, the incidence has been argumentative. Several factors account for disagreement. Neurogenic changes in the bladder and ureter often escape recognition clinically.

The intermixture of obstructive and neurogenic lesions is not uncommon. When to these possibilities there is added intermittent reflux occurring only under unusual distention, a condition infrequently obtained with the more or less irritating media used for cystography, agreement upon incidence of the condition becomes more remote.

Diagnosis is based upon cystoscopic and urographic evidence. Occasionally one sees a normal ureteral orifice on one side with the other orifice gaping. Intravesical inflammatory or neoplastic changes may account for this discrepancy. In some cases no explanations can be offered. Ordinarily the complete cysto-uretero-pyelogram gives an accurate picture of cause and effect.

Treatment is directed to the cause, if this be removable. Should the underlying condition be unalterable, transplantation of the ureters into the bowel is worth consideration, if the kidney function has not been too greatly impaired.

Aside from calculus, neoplasm, and allied disorders, to which separate description will be accorded, the acquired obstructions are those of foreign bodies, inflammatory changes, and pressure.

Foreign Bodies. It is impossible for objects to reach the ureter and lodge without skill or destiny playing a leading rôle. Because diagnostic and therapeutic instruments are so commonly introduced into the ureter, the number of accidents producing foreign-body problems is appreciable.

Tips of ureter catheters, bulbs, dilators, tents, and the many lures for ureter calculi at one time or other ultimately are brought into this group. Bullets and shell fragments may lodge in the ureter. The rarity of this occurrence bespeaks inaccessibility as much as the small size of the ureter as a target.

Recognition of disaster from some ureteral instrument, free from its controlling mechanism, may be instantaneous. Withdrawal of a catheter from which the tip is missing is an experience shared by many cystoscopists. It is rarely necessary to resort to x-ray study to determine the whereabouts of the missing portion. Of even prompter recognition is the group due to untimely disintegration of some of the ureter dilators used for the delivering of stones. A premonition of danger is palpable to the operator the moment the accident occurs. Withdrawal of the instrument and inspection usually reveal the nature of the fragment and indicate the type of intervention needed, if any.

History, physical examination, and urine analysis bring suspicion of ureter injury from bullets. The exact location of the bullet may be demonstrated by x-ray with ureter catheter in position.

Treatment of foreign bodies of the ureter is rarely necessary. Bullets, fragments of shell, et cetera, must be removed surgically, of course.

Physiology is on the side of the surgeon, and intervention is rare, indeed, in the accidents which occur in ureteral instrumentation. Should the body be of such a form or size that its removal by peristaltic activity is impossible, of course open operation must be performed as for calculus.

Ureteral Spasm. The presence of ureteral spasm has puzzled and exasperated surgeons since cystoscopy made it recognizable. The apparently unreasonable occurrence at ureter catheterization, by making urography impossible and postponing at times an urgent examination, has inspired wide interest in this phenomenon.

Little as is known anatomically concerning spasm of the ureter, sufficient clinical data are available to justify its definition as a transient or momentary contraction of a considerable segment of ureter for which an exciting cause may or may not be demonstrable.

From our knowledge of similar anatomic structures, we may infer that local irritation from stone in the ureter, inflamed areas, or neoplasm in or about the ureter may produce spasm. The likelihood that it may be produced also by remote irritation reflexly is strong.

The most commonly recognized spasm is that mentioned as occurring during cystoscopy and attempted ureteral catheterization. One or both ureters may participate. The level of occurrence is variable, but may be anywhere from bladder to renal pelvis. At a subsequent study no obstruction or reason for spasm may be found.

Anuria following ureteral catheterization is often attributed to spasm. It is likely that this is only a part of the cause in the rare suppression one sees. Certainly, prolonged ureteral spasm in functionally impaired kidneys is a grave disorder. In the production of reactions to cystoscopy, spasm plays a leading rôle.

From ureterograms obtained in all studies, spasm is demonstrable most consistently immediately below or above ureteral calculi. Occasionally in the unsplinted, injected ureter, an elongated contraction is shown by x-ray. Exposures immediately before or after such an occurrence reveal no change in caliber or an actual dilatation. This is characteristic, and provides a ready method of differentiating it from stricture.

Ureteritis. Inflammation is very much the same in the ureter as in other hollow viscera. The extent to which it prevails is obscure. Always controversial, it is maintained at one extreme by a minority that the ureter is an infrequent sufferer; opposed to this view, a majority consider ureteritis a highly prevalent disorder.

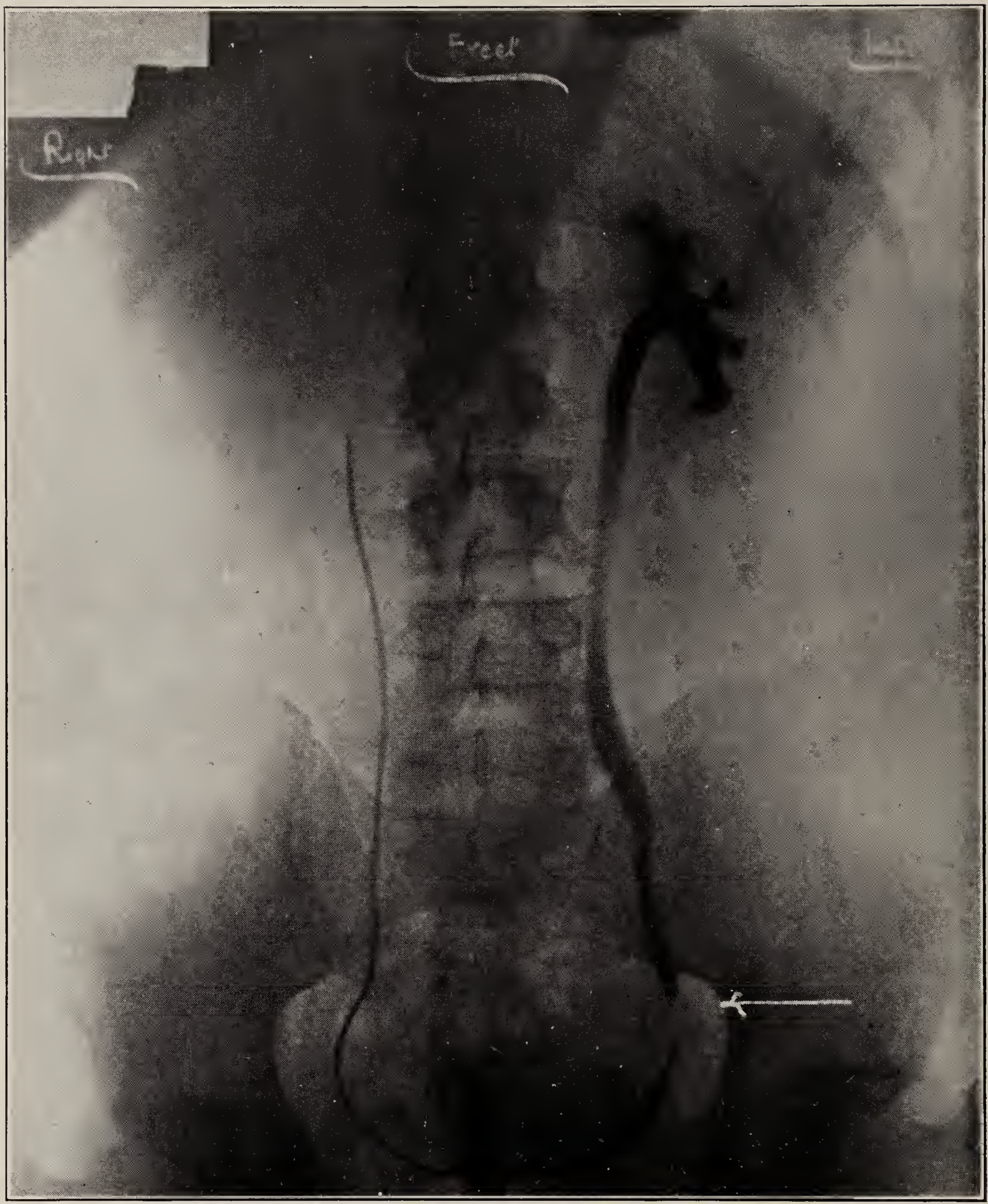


Fig. 6 shows a spasm of the lower ureter. An exposure made a few minutes later showed no narrowing of the ureter, thus distinguishing it from stricture in which a persistent narrowing is recorded. Note also the absence of hydronephrosis.

Pathology. Acute and chronic ureteritis occur. Frequently there is associated peri-ureteritis. Particularly is this true in chronic inflammatory conditions. Etiologically, metastatic, ascending, and descending forms are described. It may be said that there is no distinction between them at autopsy unless one include their source.

Mechanically the size of the ureter is first diminished. This is due in the early infection to spasm. As the process involves the mucosa and extends deeper, edema is noticeable. With chronicity occurs definite replacement of muscular by fibrous tissue with resultant distortion. Ulceration may be a part of any form.

Associated Pathology. One finds the vesico-genital tract in the ascending, and kidneys in the descending type, the direct source of infection. In the former group are included infections of the uterine adnexæ, bladder, prostate, seminal vesicles, epididymis and vasa deferentia. In the metastatic type, which is characterized by absence of change elsewhere in the urinary tract, one finds remote foci of infection in the teeth, tonsils, sinuses, et cetera.

Peri-ureteritis is common. The retro-peritoneal lymph nodes may serve as sources of peri-ureteral infection. Any post-peritoneal inflammatory process may be responsible. Areas of localized peritonitis adjacent to the ureter constitute a source of this form.

Ureteritis cystica is associated with ureteral infection in some cases. Whether the relation is incidental or etiologic has yet to be established.

Stone formation and impaction are possible in the dilatation which occurs above obstruction in the inflamed ureter. The difficulty of establishing the ureter as the site of genesis is readily appreciated.

Disturbances in the alimentary tract are commonly associated with inflammatory changes in the ureter. Enteritis and colitis are common but less often mentioned than nausea and vomiting.

Pathogenesis. It goes without saying that the organisms responsible for the ureteral infection are identical with those of the offending focus.

Descending infections are usually part of a pyelo-uretero-cystitis, and the process is one of extension both by continuity of surface and by inoculation from the passage of infected urine.

Ascending infections of the ureter are of two definite groups: those due to continuity of surface with the bladder and reflux, and those due to contiguity of surface with the intra- and post-peritoneal structures.

Metastatic infections are more purely clinical in occurrence than the first two forms. The subsidence of symptoms after removal of various foci, rather than demonstrable anatomic cause and effect, is the basis of recognition.

Diagnosis of ureteritis in its acute and sub-acute forms is difficult. It is impossible at present to identify organisms peculiar to the ureter and establish the priority of their location. It should not be said that metastatic ureteritis can be diagnosed only at autopsy. There are clinical criteria upon which this diagnosis may be made.

History is important, and usually begins with sudden onset of pain or urinary frequency in an individual previously free from such disturbances. The finding of only occasional small clumps or slightly increased numbers of white blood cells in the urine of a patient whose urine has been previously normal is sometimes the only sign of ureteral involvement by an infection elsewhere in the body. The history in the descending form is usually one of fever and pain with or without urinary symptoms. Renal tenderness and pyuria classify these as pyelitis and the condition of the ureter is usually ignored.

In ascending ureteritis the history is of previous infection of the bladder or genital tract followed by pain in the back. This may or may not be associated with fever and frequency.

Sinus, tonsil, or other upper respiratory infections may precede metastatic infections. Necessity for dental work and the patient's knowledge of dental infection may be valuable in arousing the suspicion of the examiner.

Physical examination is of positive value in most cases. There may or may not be tenderness over the bladder, ureter, and kidney regions. In the acute forms there is marked tenderness over the ureter, particularly upon pressure over the lower portion.

Pyuria after an acute infection outside the urinary tract, along with frequency and pain, is of high diagnostic value in the recognition of upper urinary disorders of the acute and sub-acute kind. The absence of all urinary findings with this clinical picture is, nevertheless, suggestive of ureteral infection.

Treatment of acute ureteral infections must be directed to the cause, when this is possible. Most of the sufferers do not appear for study during the acute illness or, if they do, the urinary portion of their condition is not impressive enough to suggest study at the time. Certainly many of the obstructive changes in the ureter could be ameliorated by curiosity concerning the nature of the mild " cystitis " and pyuria which so commonly complicate acute infections all over the body. Unquestionably many of these represent ureteral infection. Could they only receive prompt recognition, much suffering might be prevented.

Chronic Ureteritis (Stricture). The nature and incidence of ureteral stricture has provoked more discussion among surgeons in recent years than any other uropathy. Since the basis of disagreement lies in concise definition, it would seem that some accurate description of the term " stricture " as applied to the ureter could be formulated acceptably to all. To a certain point this is possible. There is agreement that organic diminution in the caliber of the ureter due to cicatrization constitutes stricture. The anatomic structure of the narrowing being capable of demonstration so rarely, controversies have arisen concerning the number which are congenital, non-inflammatory in character, and unassociated with hydronephrosis.

To one group, every narrowing which is capable of producing obstruction, functional or structural, is stricture and, as proof, a clinically favorable response to treatment is acceptable. One need not be partisan to recognize the fallacy to which this school is subject. Because it may not always be detected by objectively demonstrable data, its opponents criticize the emphasis personal enthusiasm lends to its incidence.

The second group recognizes as stricture only such narrowings as result in demonstrable anatomical obstruction, hydronephrosis or dilatation of the ureter above the narrowing. This view ignores incipient obstruction, and discounts too heavily the weight of trained clinical observation.

We accept a definition which recognizes the necessity for the observer to interpret the presence and extent of a given lesion not only on the basis of cystoscopic and x-ray observations but also upon the response to remedial measures employed. The proponents of the narrower view are ably prepared to discount over-enthusiasm occurring inevitably with the entrance of this personal element. We define stricture as any organic diminution in the caliber of the ureter productive of any degree of obstruction to exit of urine from the kidney.

Diagnosis of stricture is based upon a history of its occurrence, most frequently in women between the second and fourth decades. The onset is usually gradual, following days to weeks after some form of acute infection. The first manifestations, frequency, pain in the back or abdomen, may be very mild. Pain is persistent and frequently cramp-like in character. The distress may be low enough on the right side to simulate appendicular colic. Sometimes its persistence in mid-abdomen suggests an enteric or gastric lesion. Its vagueness, unless associated with renal pain, tenderness, or urinary frequency is its most suggestive feature.

Frequency of urination is a fairly uniform accompaniment of stricture, particularly stricture in the lower ureter. Usually it is confined to that period of the day in which physical exertion is greatest. Not infrequently there is nocturia. Frequency brought on by motion and relieved by rest is common. When there is no change in bladder capacity, and urgency is induced by activity, the condition may be strongly suspected.

Cystoscopy and Urography are indicated in every abdominal or loin distress and in every frequency not accounted for by extra-urinary

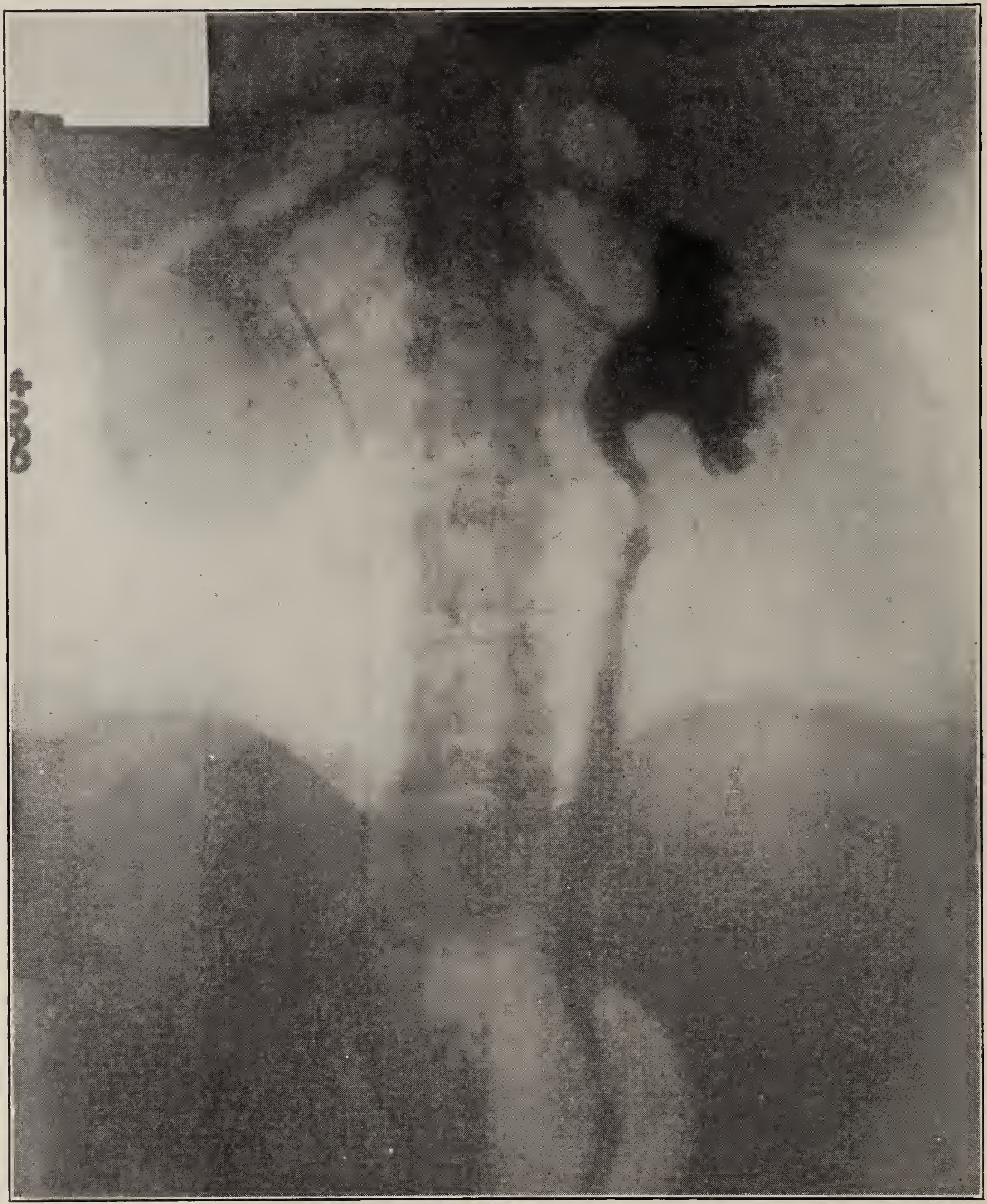


Fig. 7 shows a typical stricture of the ureter just below its junction with the pelvis. Note the definite hydronephrosis above and the dilated ureter below the point of narrowing. Hydronephrosis is mechanical. The dilated ureter is probably atonic as no obstruction was noted in the lower ureter.

changes. The exploration of the ureter by wax-tipped catheters or bulbous bougies gives prompt information of the size and location of narrow-

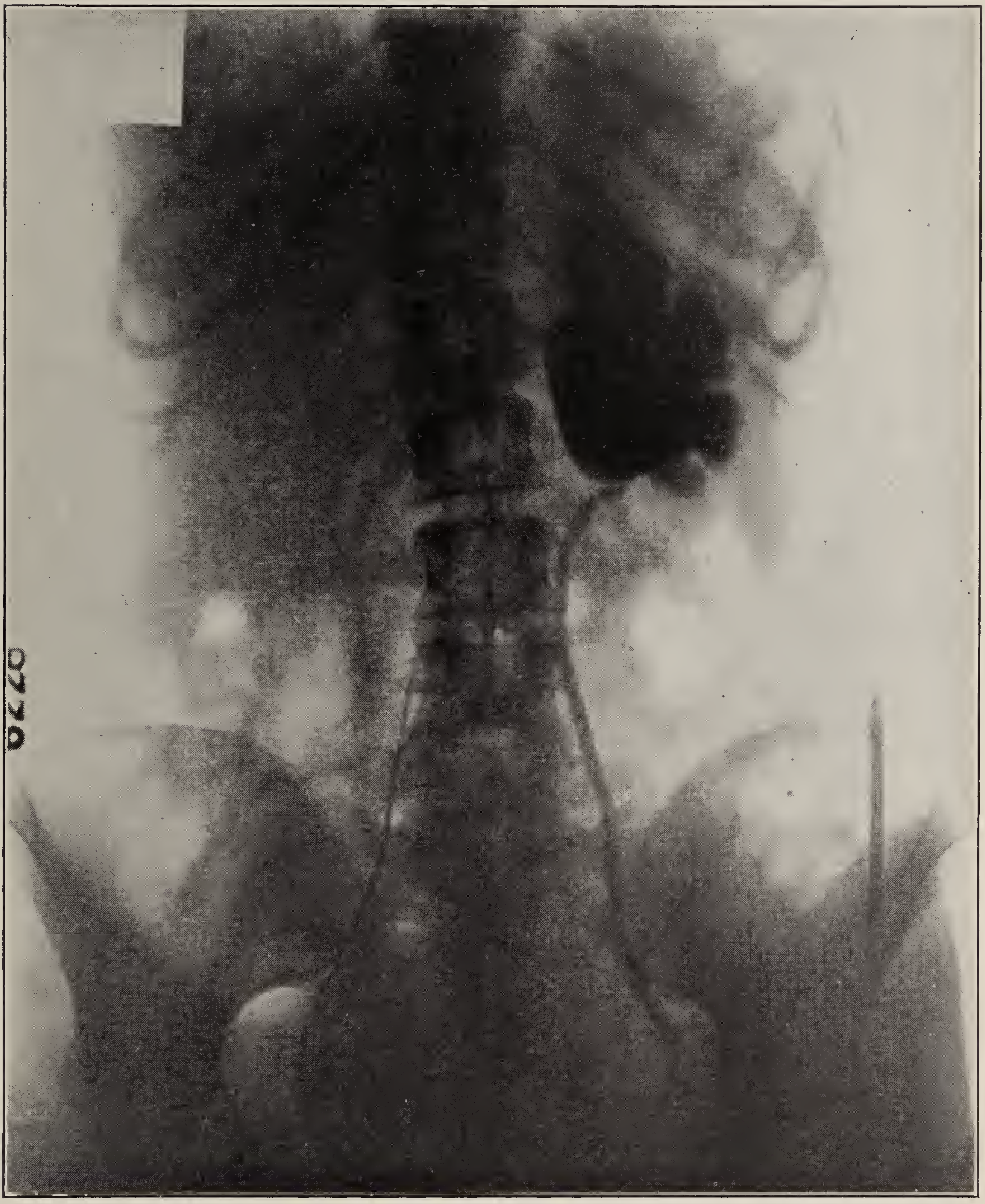


FIG. 8. This is another example of pyelectisis and dilatation of the calyces due to stricture of the ureter.

ings. It is upon pyelo-ureterography, however, that the final determination usually rests. The most important function of the bulb is to direct the attention of the urographer to suspicious narrowings the character of which may be questionable.

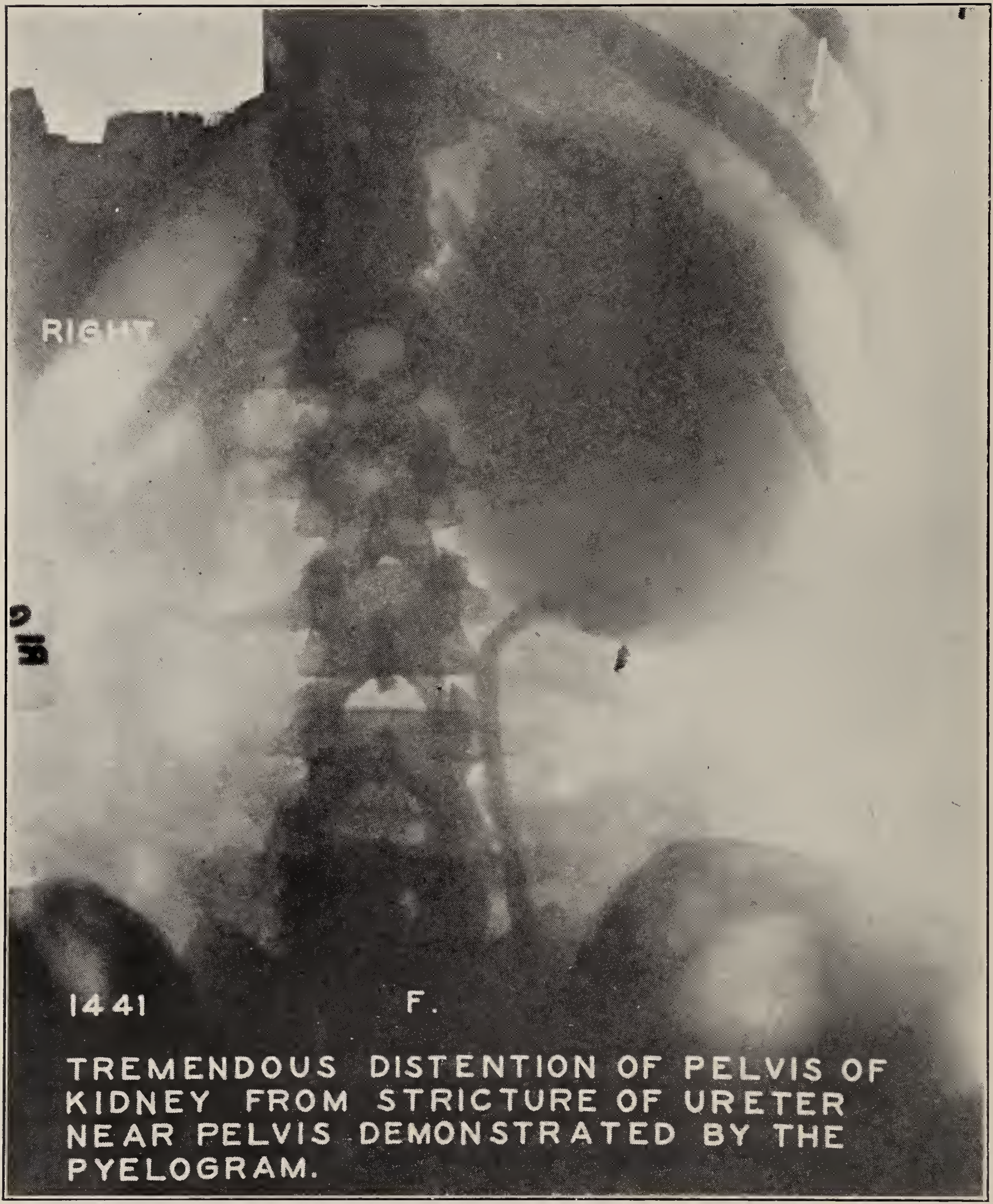
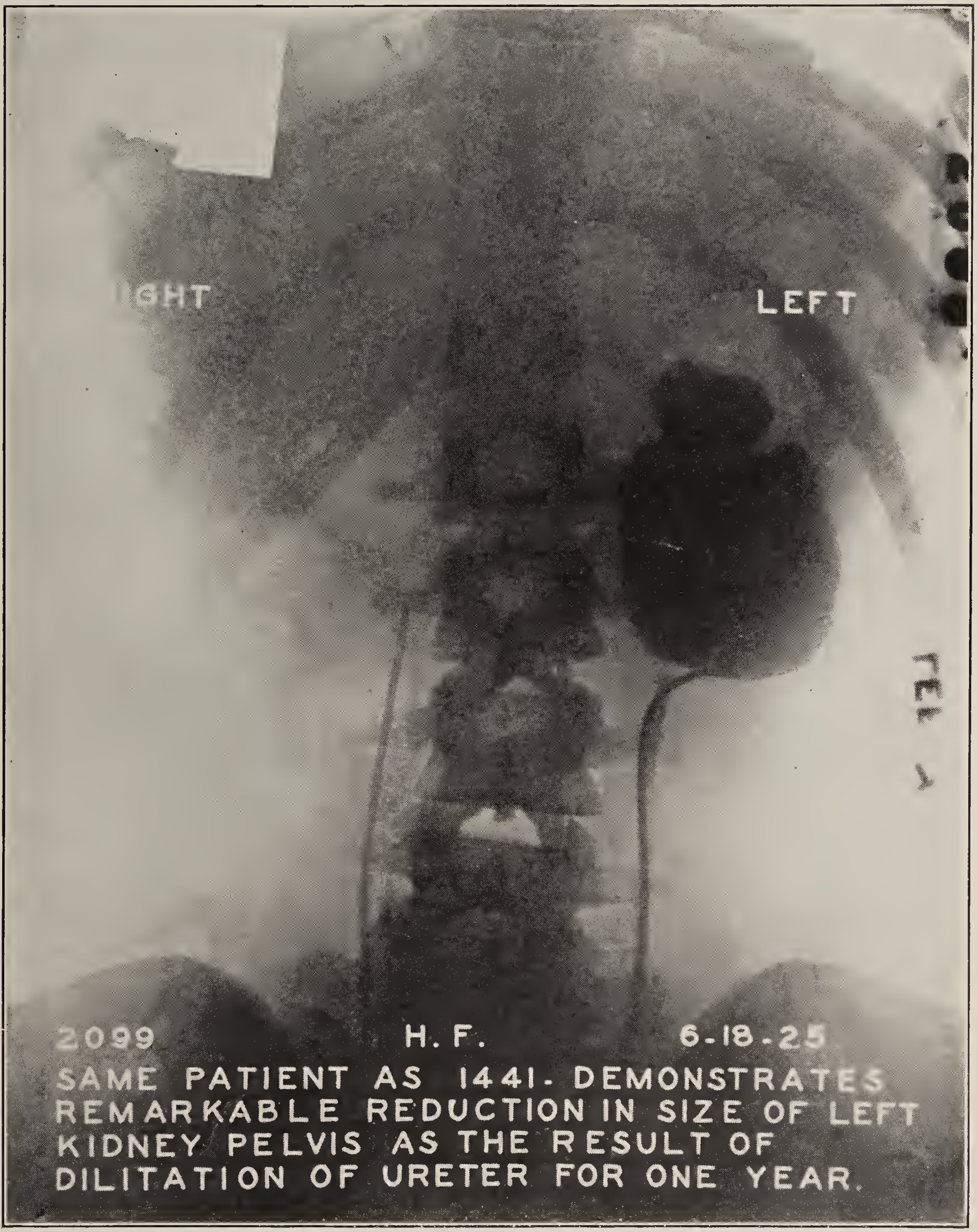

RIGHT
1441
F.
TREMENDOUS DISTENTION OF PELVIS OF KIDNEY FROM STRICTURE OF URETER NEAR PELVIS DEMONSTRATED BY THE PYELOGRAM.

FIG. 9 shows a massive hydronephrosis due to stricture of the upper ureter. There would seem to be no functioning kidney in this instance.

A distinct narrowing of the ureter, shown in consecutive uretero-pyelograms persistent in size and location, particularly if hydro-ureter or nephrosis accompany it, is accepted as diagnostic. In addition, as has



SAME PATIENT AS 1441- DEMONSTRATES REMARKABLE REDUCTION IN SIZE OF LEFT KIDNEY PELVIS AS THE RESULT OF DILITATION OF URETER FOR ONE YEAR.

Fig. 10 is a pyelogram of the same kidney seen in Fig. 9, and demonstrates the improvement resulting from dilatation. Note the marked diminution in the size of the pelvis and the paucity of dye in the cortex.

been said, a favorable response to the examination is acceptable as evidence in our experience.

Treatment is twofold: removal of foci from which infection may arise, and provision of free drainage by dilating the strictured segment.

The pelvic junction, the intramural and the vesical end of the ureter present special problems. Elsewhere the ureter is dilatable with comparative ease.

The strictured meatus can rarely be dilated successfully without meatotomy. Fulguration of the loose upper flap of the orifice is readily carried out cystoscopically. The cystoscopic scissors are just as adequate but excite more active hemorrhage. The opening should be so enlarged as to permit easy introduction of large catheters. Dilatations should be given as often thereafter as is found essential to the maintenance of normal caliber.

Once diagnosis of stricture has been made, the patient is instructed concerning the probable chronicity of the disorder and the importance of finding all possible foci of infection. Treatment is begun by passing the largest size catheter or bougie which can be introduced easily to the pelvis of the kidney. Depending upon the reaction to this treatment, an interval of five to twelve days is allowed to elapse. At each sitting the dilatation is carried higher until the maximum for that patient is attained with relative ease. In the female this may be accomplished with a minimum of effort through the Kelly cystoscope. The Pan-endoscope of McCarthy allows large size bougies to be used freely. More recently the Buerger instrument has been modified by Ravich to permit maximal dilatation with a single large bougie. Approximately the same dilatation may be achieved by multiple bougies through the ordinary operating and catheterizing instrument.

As the caliber of the stricture increases, the interval between dilatations may be prolonged. In patients with a definite focus, which is removed, two or three dilatations may be followed by complete relief of symptoms and no recurrence. Less fortunate individuals will be dilated at intervals of two to six weeks for months, and after subsidence of symptoms be requested to return every three or four months for observation, at which time any difference in the caliber of the previously strictured segment may be noted and the interval altered accordingly.

Some unfortunates, in whom the nature of the focus remains obscure or baffles removal, obtain relief for short periods only. The distress recurs and persists unless dilatation be given. The accuracy with which one may prophesy the date of distress recurrence in these patients is such that it may be anticipated and treatment-intervals regulated accordingly.

Rarely one finds a stricture of such elasticity that surgeon and patient despair of its relief from dilatation. In these an indwelling ureter catheter

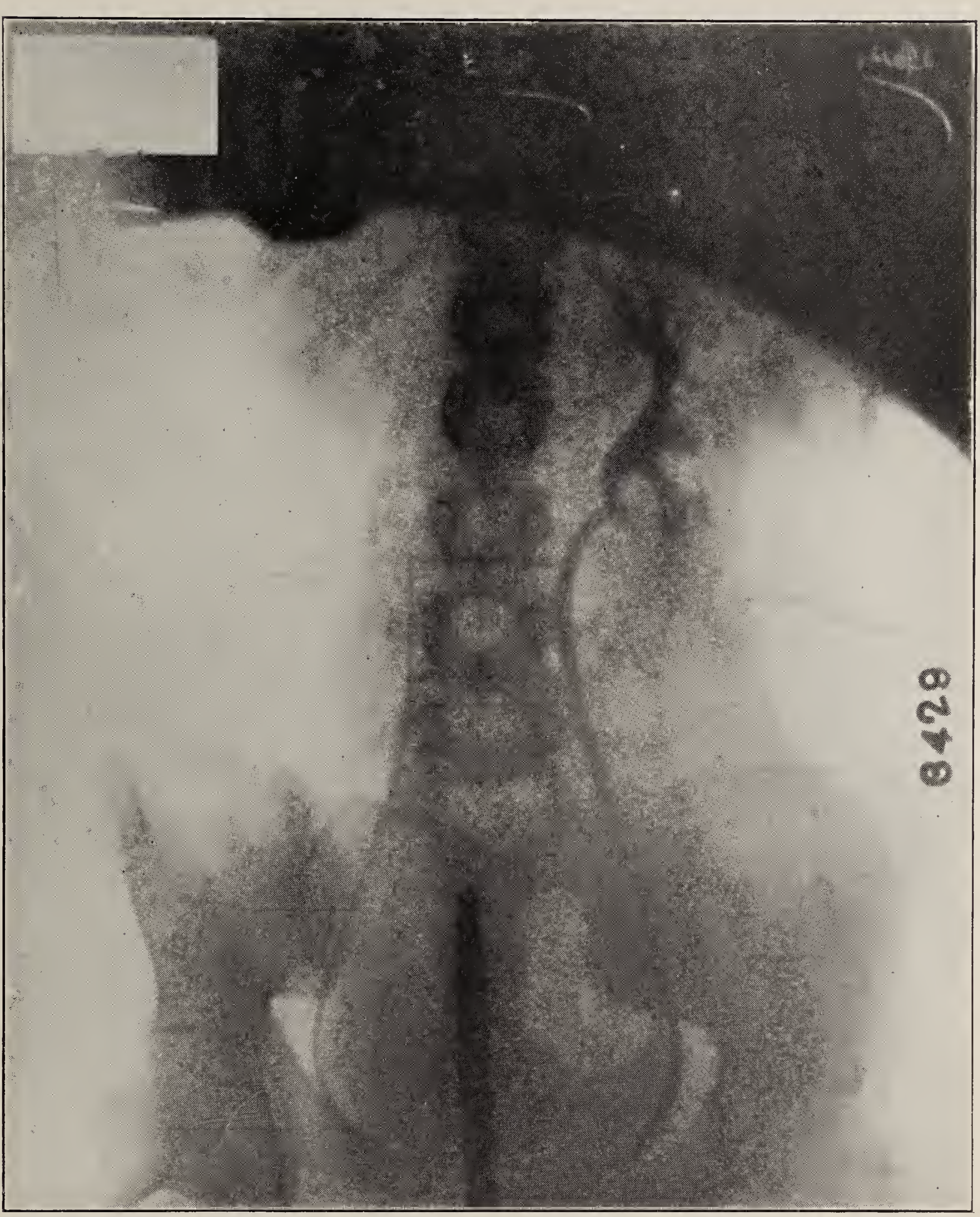


FIG. 11. A complete looping of the ureter at the pelvi-ureteral junction productive of symptoms but as yet causing no hydronephrosis.

is left in the kidney from three to five days, following which the length of the relief period is observed. If, after several such efforts, relief is not obtained for a reasonable period of time, exploratory operation is justified. One finds usually at operation extensive peri-ureteral changes, correction

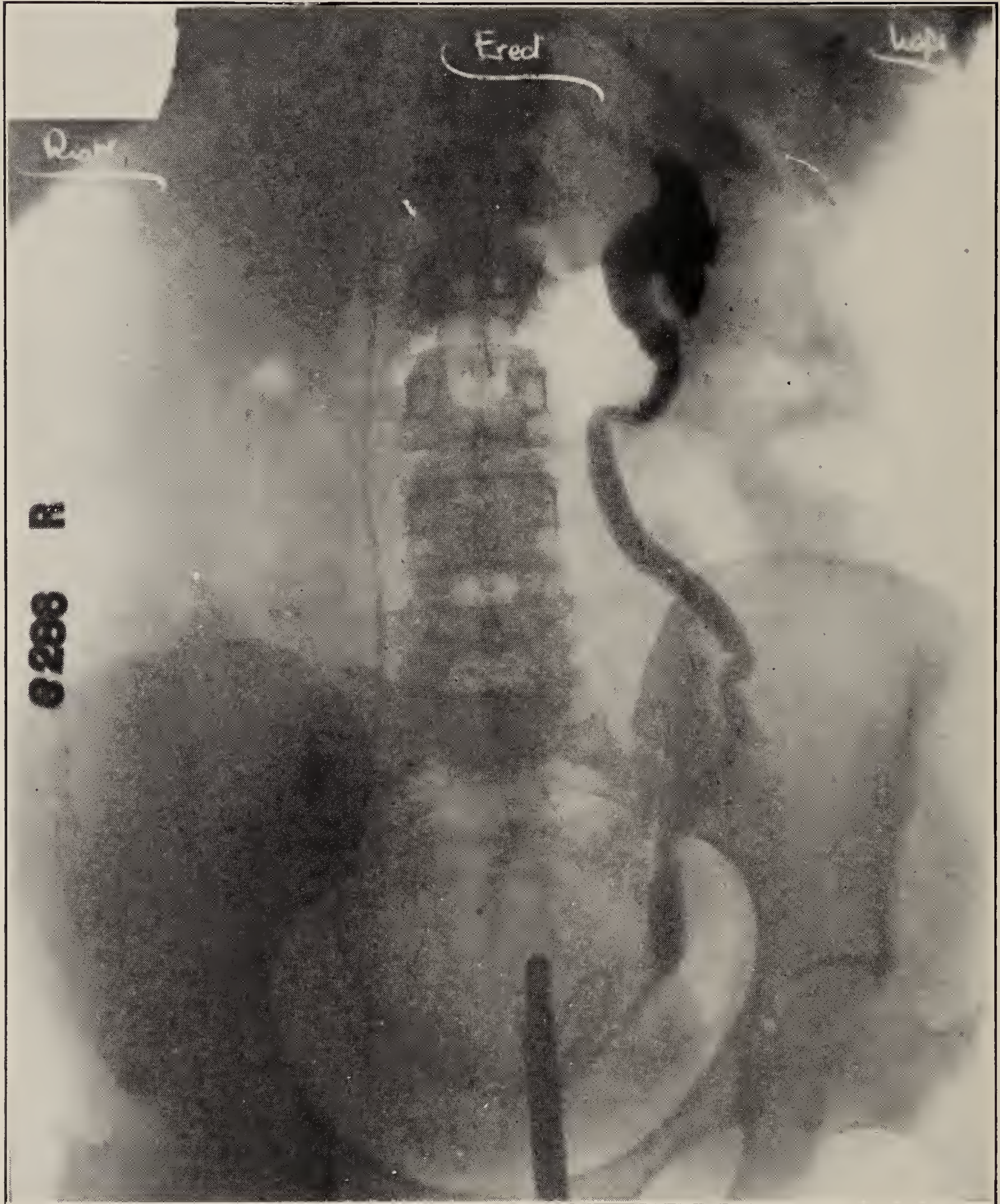


FIG. 12. This is shown to demonstrate the long, kinked, relaxed ureter and its tortuosity. There is moderate dilatation of pelvis and calyces, but only after a long period of time. There is some obstruction at the lower end of the ureter which, as much as the kink, was the cause of symptoms.

of which is possible by freeing the ureter. Should infiltration be too dense for this, plastic enlargement of whatever type the situation demands should be carried out.

Stricture of the upper ureter, by its distance from the cystoscope and its proximity to the kidney, constitutes a special problem. If dilatation cannot be secured in the above manner, one must resort to open operation. There have been devised effective procedures for the relief of these obstructions, description of which is given under operative treatment.

Impassable strictures of the ureter in all but the lower end require open operation. At the lower end, particularly in the vesical portion, it is sometimes possible to penetrate a cicatrized ureter with the aid of fulguration. The ordinary electrode, used in treating bladder tumors, is passed to the obstruction and momentary coagulation repeated every seven to ten days until the obstruction is passed.

The patient should be warned of the possibility of perforation and reaction. We have never felt justified in using this method or any of its modifications in strictures above the vesical junction of the ureter.

Kinks and Torsion. The rôle of the distorted ureter in the production of abdominal, vesical, and renal symptoms is well known. More unanimity of thought obtains concerning its incidence and clinical importance.

Kink of the ureter may be defined as an angulation due to excessive length, ptosis of the kidney or aberrant renal vessels. It is often productive of symptoms resembling stricture. It may be asymptomatic, some observers considering it only rarely of clinical significance.

Torsion or twisting of the ureter is produced by adhesion of the ureter to the peritoneum and by displacement due to intraperitoneal or postperitoneal masses. It is more often productive of symptoms. Subjective phenomena produced by it are not characteristic but usually suggest ureteral strictures. Retroperitoneally, any mass or inflammatory process in contact with the ureter may kink, twist or distort it. An intraabdominal mass of sufficient size may so stretch the peritoneum to which the ureter is adherent as to produce this effect. Peritonitis often performs the same feat.

Twists and kinks from rotated or ptosed kidney are frequently unrelated to any inflammatory process. The pathology of this distortion varies with the acuity of angulation or obstruction, and the absence or degree of infection. There may be no demonstrable change in the structure or function of the ureter. Infection may extend into the wall of the ureter producing the changes of stricture formation.

Diagnosis may be suggested by gradual onset of symptoms following an acute abdominal or genital inflammation. Not infrequently during convalescence from laparotomy, urinary symptoms suggest inclusion of

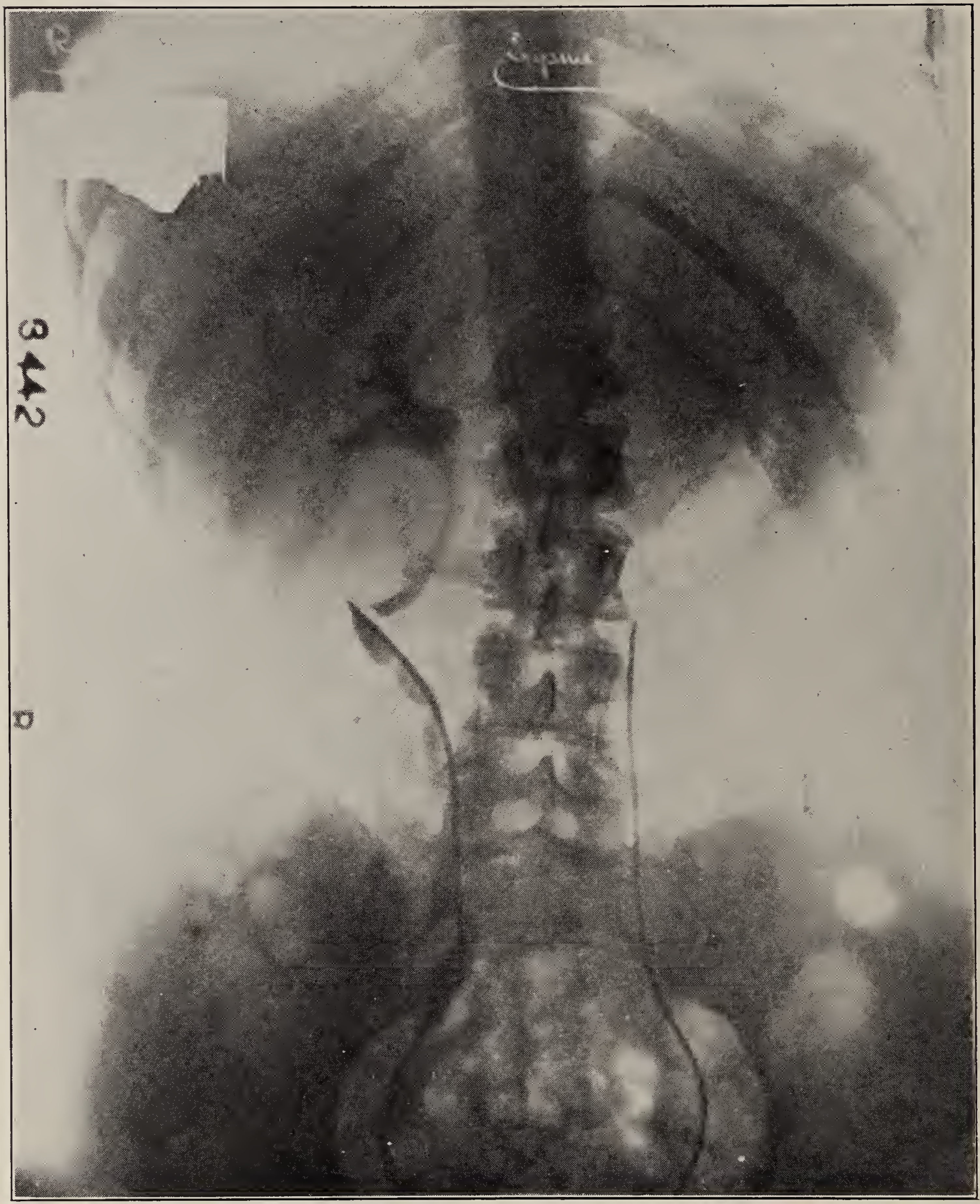


FIG. 13. This is another example of kinked tortuous ureter made more obvious by a catheter which is obstructed at the point shown. The beginning hydronephrosis and the patient's response to treatment which eventually succeeded in passing the obstruction noted, make possible a diagnosis of an actual obstructing kink.

the ureter in the inflammatory process. Thus frequent, urgent urination, pain in the bladder, abdomen, or flank with slight pyuria or hematuria in

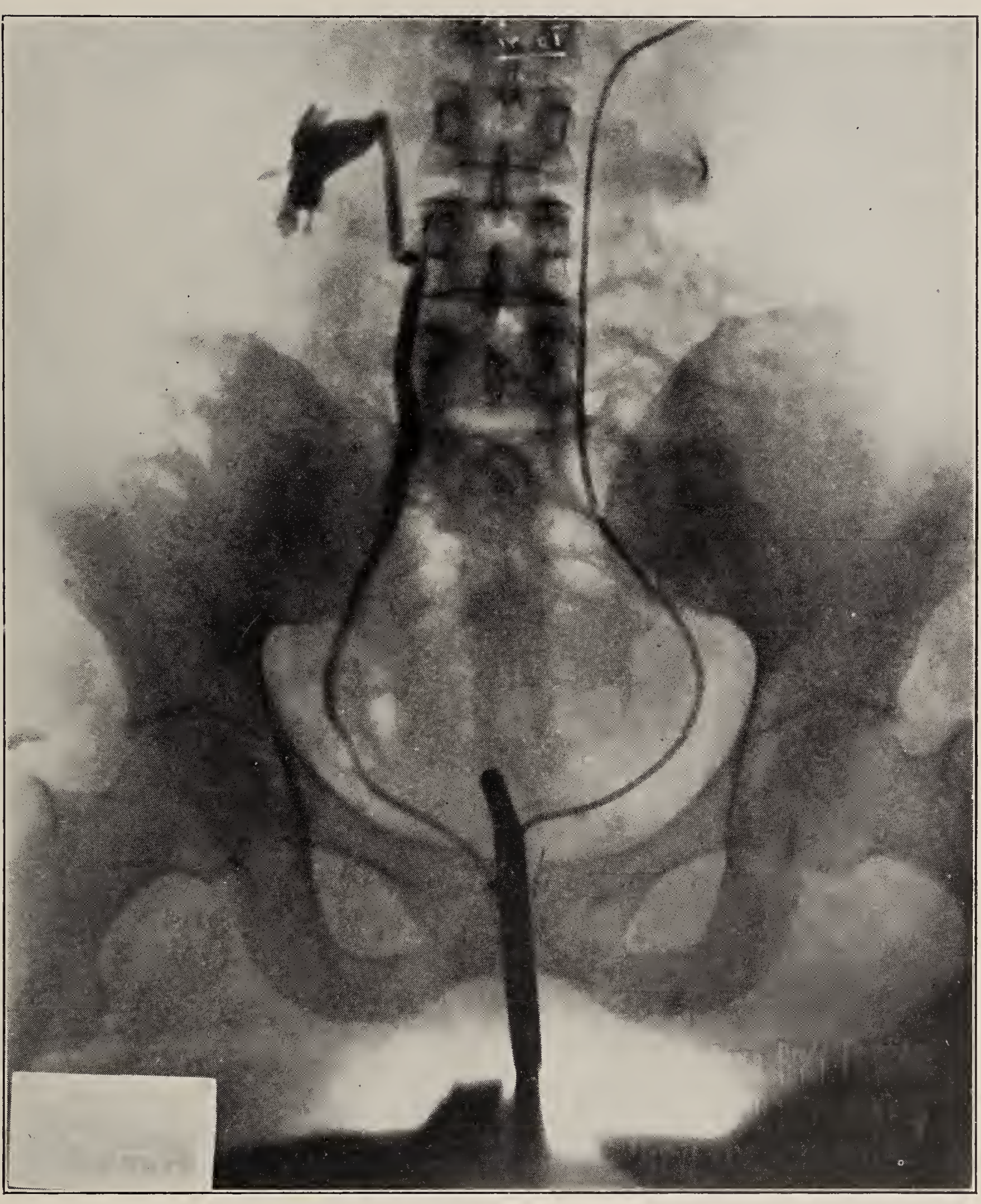


FIG. 14 shows a ptosis of the kidney in the erect posture with angulation of the pelvi-ureteral junction a short distance below which is a double right-angle kink. No acute obstruction but a chronic low-grade obstruction is shown.

a patient with previously normal urine, occurring during the course of an acute abdominal illness or during convalescence therefrom, is suggestive of ureteral involvement.

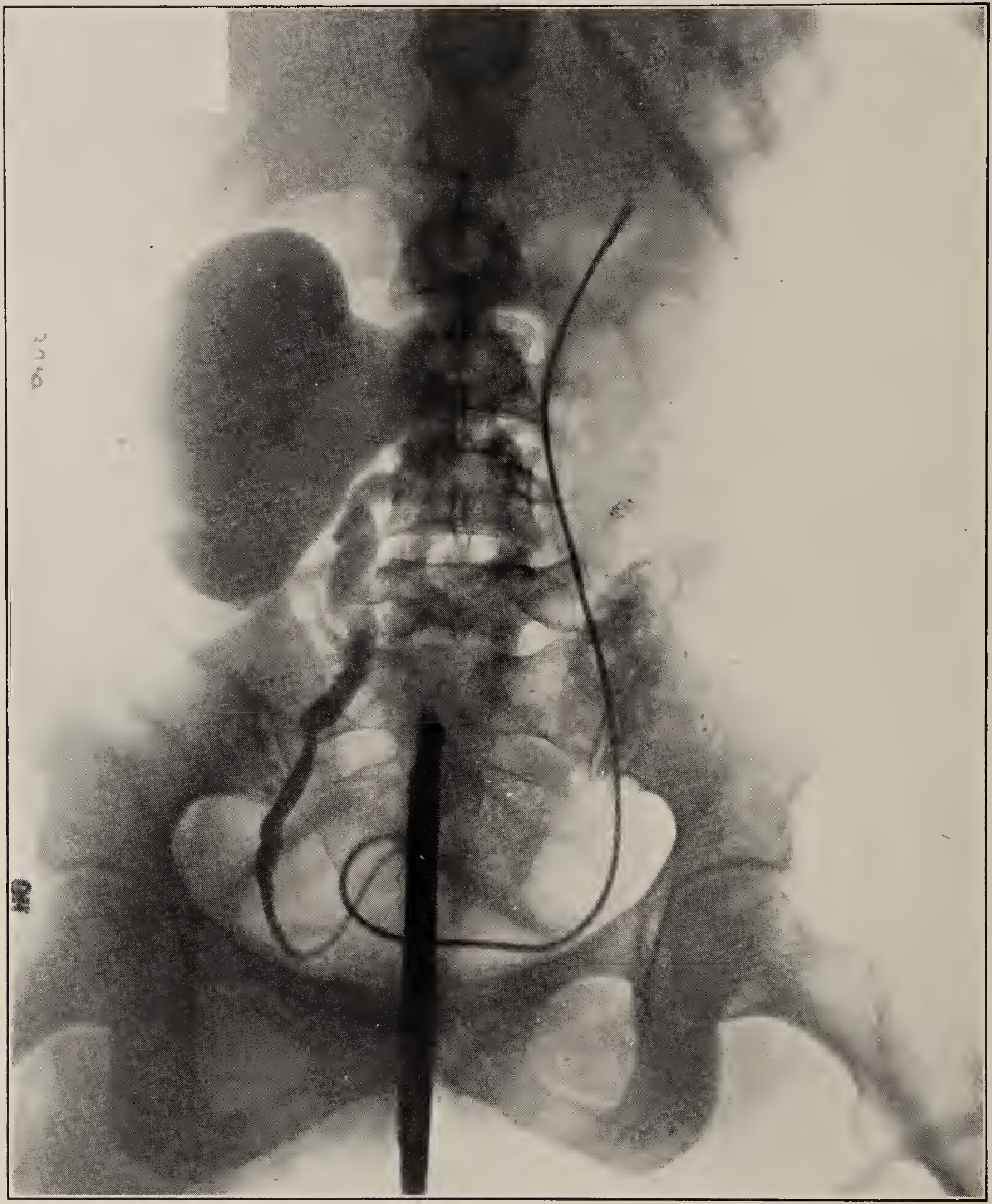


FIG. 15 shows a massive hydronephrosis with no obstruction at the pelvi-ureteral junction and no stricture formation. The loss of tone most marked in the mid-ureter below the manifest twisting justifies the diagnosis of an obstructing twist of the ureter.

In ptosis one obtains a history of afternoon fatigue in an active nervous individual. The condition is worse at the end of the day, absent in the beginning of the day, and is relieved frequently by rest in the prone

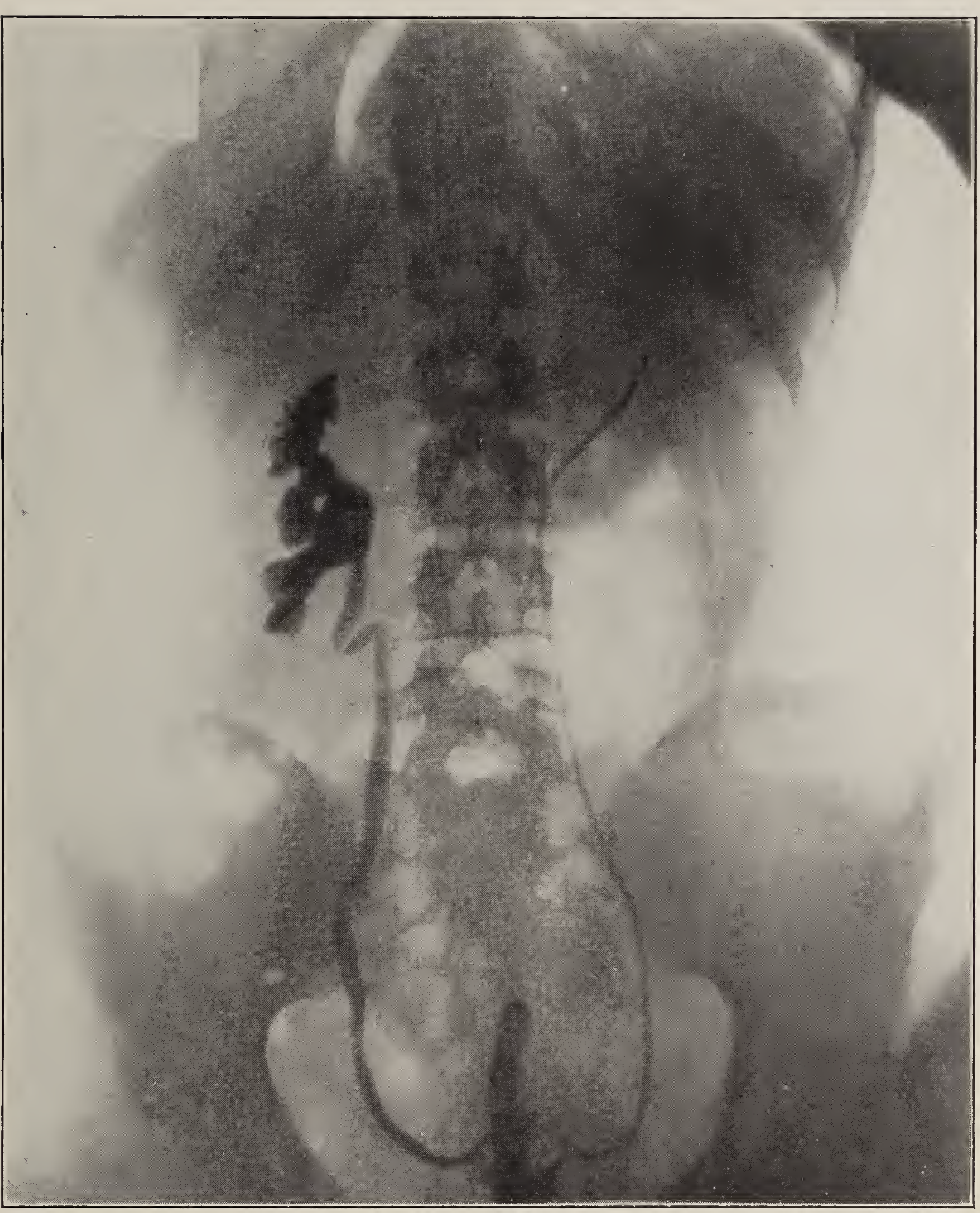


Fig. 16 shows a hairpin kink of the upper ureter with moderate hydronephrosis. This type of kink is most often produced by an adhesion to the posterior surface of the peritoneum from peritonitis.

position. When this history precedes by weeks or months the beginning of continuous pain in the abdomen, flank, or bladder region, with or without urinary symptoms, a fairly definite opinion may be formed.

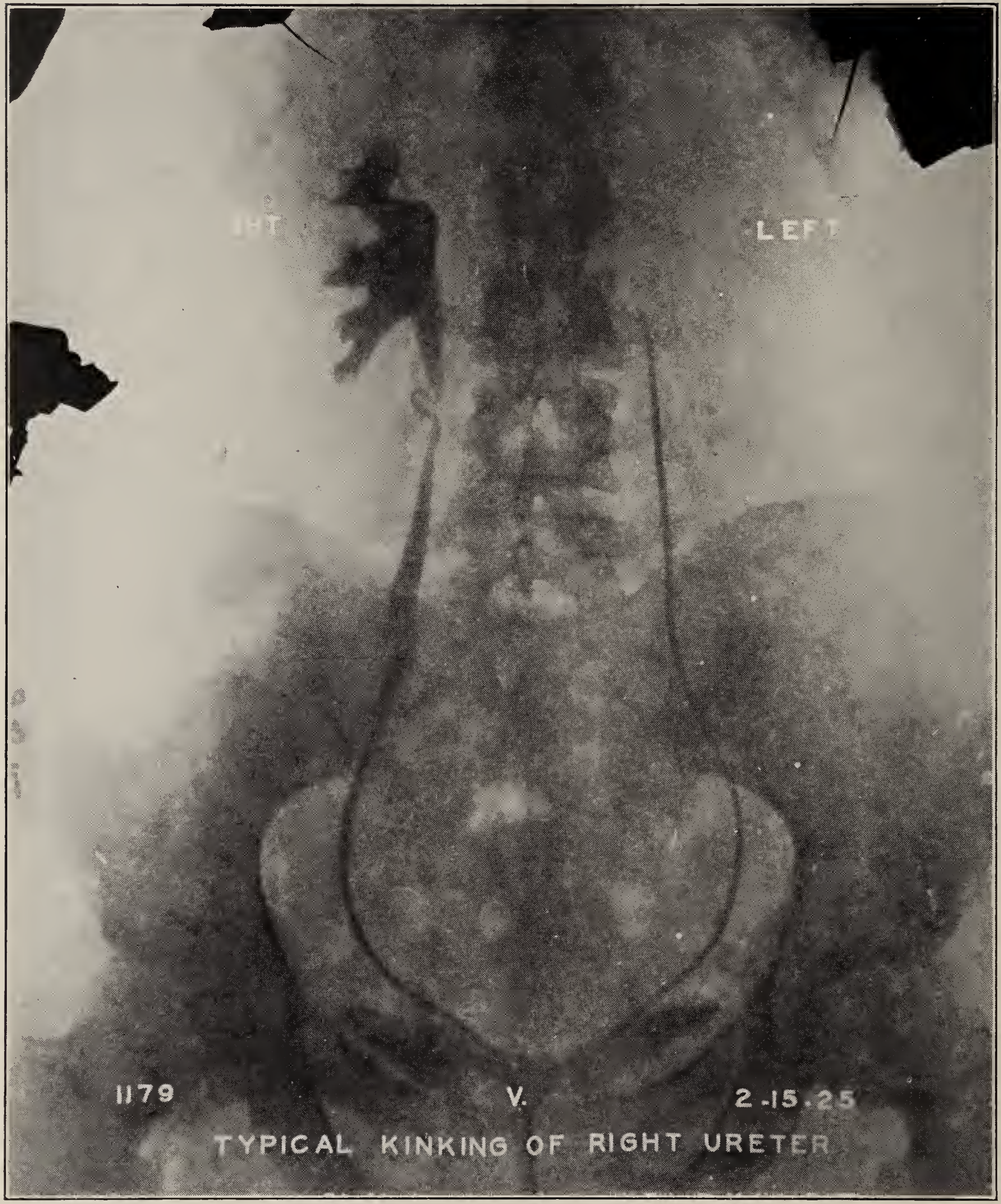


Fig. 17 is another example of postperitonitis kinking of the ureter which was completely relieved by dilatation and canalization of the obstructed ureter.

Physical examination is usually disappointing except in that group in which ptosis is a factor. Palpation of a freely mobile, low kidney is informative in the precystoscopic appraisal of the patient with a history of exertion or fatigue distress.

Cystoscopic and Urographic Study. Diagnosis is made final by the

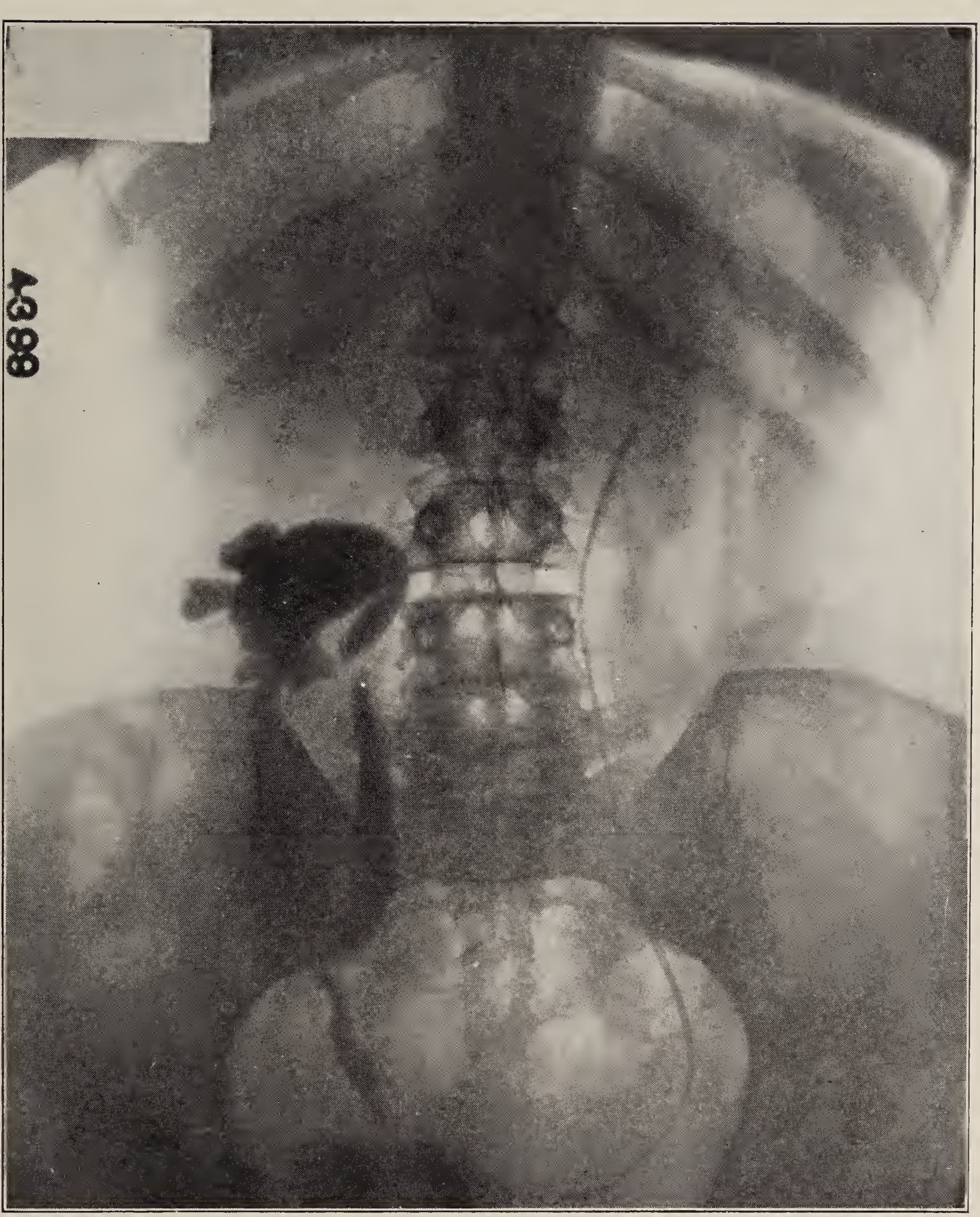


FIG. 18 shows marked ptosis, stricture of the upper ureter. The characteristic atony below and mechanical dilatation above.

urographic examination. Pyelography in the prone and ureterography in the erect posture give prompt evidence of distortion. In ptosis, the angulation is noted only in the erect position. Fixation from whatever cause is usually constant in both positions. An intra-abdominal mass may shift in the upright position. The resultant change is helpful in differentiating it from retroperitoneal mass. Usually a mass which displaces the ureter to any extent is retroperitoneal. The exception is very large intraperitoneal mass.

Treatment is necessary in all cases which have symptoms of obstruction. In ptosis a well-fitted belt is effectual in many patients. If, in addition, ureteral dilatation and renal pelvic lavage are carried out on the affected side or sides, the majority of these patients may be kept fairly comfortable. When distress is definitely of ureteral origin and relief is not given by these conservative measures, nephropexy is in order.

Distortions due to adhesions can frequently be relieved symptomatically by ureteral dilatation. Should this fail to improve the symptoms, uretero-lysis should be carried out and such plastic procedures as the individual situation requires, performed. Obviously, torsion due to tumor mass of whatever source may be relieved only by removal of the mass.

Compression of the ureter by tumor mass, lymph glands, aberrant vessels, appears as a part of the definite clinical picture of ureteral obstruction. Frequently only the obstruction, without hint of its cause, is demonstrable by urography. Only at operation is the condition recognized. Occasionally at autopsy, obscure ureteral obstruction is found to be due to metastatic lymph node enlargement of inflammatory or neoplastic character.

No routine procedure is advocated in its detection or handling. The wisdom of open operation and exploration of all persistently impassable or undilatable obstructions, particularly in the presence of diminishing renal function is manifest. Less obvious are the passable but undilatable obstructions, treatment of which fails to improve the hydronephrosis both clinically and functionally.

CALCULUS OF URETER

The calculi which enter, traverse, or become impacted in the ureter constitute interesting and dramatic situations. The reader is referred to the chapter on Surgery of the Kidney for a discussion of the origin and nature of renal calculi. Occurrence of primary lithiasis in the ureter is possible, but only under unusual circumstances. The difficulties encountered in any attempt to establish a given calculus as ureterogenic are such as to discourage all but our boldest.

Pathology. Changes in the ureter due to stone are contusion, laceration, and perforation. The entire ureter, or any portion, may be intensively hyperemic, and spotted with petechiæ. There may be small, scattered lacerations. Perforation may occur into the postperitoneal space, the peritoneum, or directly into the bowel.

A second type of change is that due to impaction. The ureter reacts to foreign bodies in a definite way. There is intense peristalsis to the point of exhaustion, followed by relaxation and eventual cessation of activity. Eventually the entire ureter may react in this way. Should the impaction persist, atrophy of the musculature may occur. The addition of infection to these changes intensifies them. Instead of an atrophic thinning of the ureteral wall, edema and infiltration of the mucous and muscular coats occur. These changes eventuate, should they continue over a sufficiently long period, in fibrous replacement of the muscular layers of the ureter.

Associated pathology includes the hydronephrosis and pyonephrosis of calculus disease. The added trauma of obstruction by impacted calculus is often sufficient to light up dormant infection. Pyelo-nephritis and cortical abscess may be seen.

Diagnosis is frequently made from the appearance of the patient doubled up by paroxysms, between which one may obtain a history of severe, knife-like pain originating suddenly in the loin. After remaining localized a variable period of minutes to hours, during which its severity may decrease, radiation downward is noted. This may terminate in the mid-abdomen, bladder, or genitalia. Nausea and vomiting are common. In protracted impaction, vague gastro-intestinal symptoms of less startling character are seen, and the pain is of the dull, aching type seen in hydronephrosis.

Small sand-like particles are passed with considerably less pain and in a fraction of the time required by a pea-sized calculus. Hours to days may be necessary to expel a single stone. If impaction occurs, this period may be prolonged indefinitely.

Anuria occurs in calculus disease often enough to make its gravity well known. Seen usually in conjunction with calculus disease of the kidney, the first symptom of sufficient magnitude to attract attention from the pain may be the failure of the patient to secrete urine. In its minor form, anuria may be transient, secretion being resumed in a few hours. Not uncommonly its persistence necessitates operative intervention.

Physical signs include tenderness over the kidney and ureter regions. The abdomen may be rigid on the affected side. Spasm of the dorsal musculature on the tender side is quite constant.

Urine analysis usually reveals a scanty, smoky, or hazy urine in which red blood cells are demonstrable microscopically. White cells are usually increased and may occur in clumps.

X-ray of the urinary tract reveals in approximately 90 per cent. of proven cases a shadow indicative of stone.

Cystoscopy need not be long delayed. It is well to let the acute attack subside, should this occur within a reasonable period of time. The persistence of excruciating pain, nausea, and vomiting for over twenty-four hours indicates cystoscopy for therapeutic as well as diagnostic purposes.

The findings are usually quite definite. Often upon introduction of the cystoscope, the reddened, angry appearance of the orifice suggests ureteral disturbance. Occasionally the lower end of the ureter is occupied by a stone, part of which may present at the orifice or be the cause of obstruction almost immediately after a catheter is threaded through the orifice. More often one encounters obstruction to or by which a wax-tipped catheter may be manipulated. There is also a metal-tipped catheter which connects with a stethoscope to permit the operator to hear a click at the time of contact between the tip and the calculus.

Thus one sees evidence of ureteral disorder, demonstrates the obstruction, obtains scratches on the wax-tipped catheter, and may hear the metallic sound of contact. This is sufficient evidence for practical purposes and in non-opaque calculi may be all that is obtainable.

Opaque calculi may be more graphically and permanently demonstrated by combining x-ray with the above procedures. The presence of a shadow at the tip of the catheter, which cannot be passed farther, or shadow alongside the catheter, is informative. In the latter instance, deflection of the tube angle between halves of a split exposure demonstrates the identity of the plane occupied by stone and catheter as well as the reality of their contact.

Injection of sodium iodide, when one can pass the obstruction with the catheter, outlines the ureter and stone by its overflow so that the shadow is included in the ureterogram. Should the ureter be impassable at the stone, injection of a quantity of the dye will result in considerable distress; the ureter and pelvis above are frequently not injected at all, and the value of the exposure is the demonstration of shadow and catheter separated only by dye.

Non-opaque calculi may be suspected when the ureter is dilated at or immediately above the level of obstruction to ureteral catheter. The injection of air has succeeded in providing a contrast against which these less dense stones may be seen. In doubtful cases it has real value.

Treatment of Calculus. The forcing of large quantities of fluid

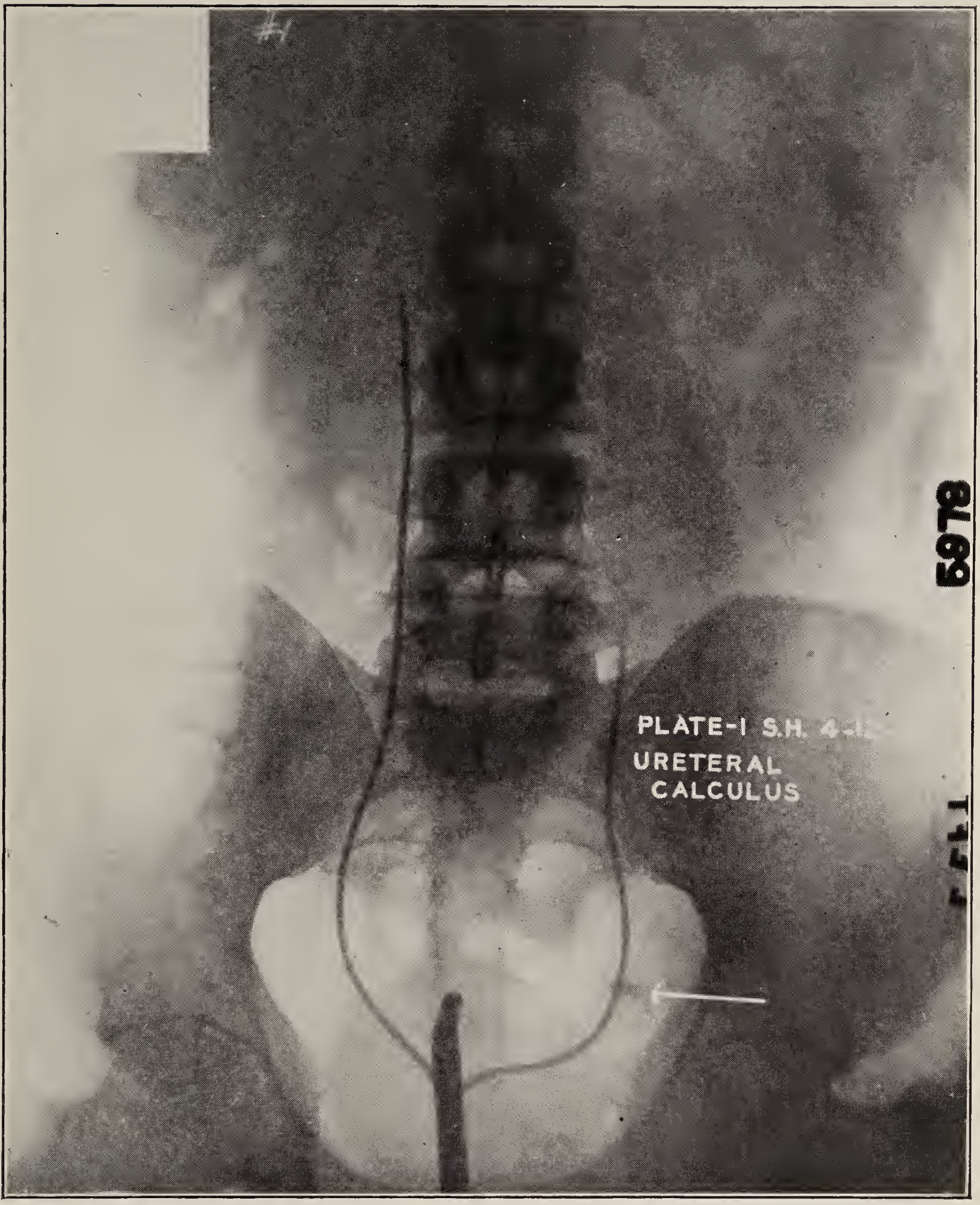


FIG. 19 shows a calculus in the lower ureter. There is no hint of the presence of the kink above except that the catheter met obstruction in the mid-ureter.

and urinary antiseptics, together with adequate quantities of narcotics, has long been routine. The value of morphine is enhanced by atropine and other anti-spasmodics. Pituitrin enjoys a reputation in the stimula-

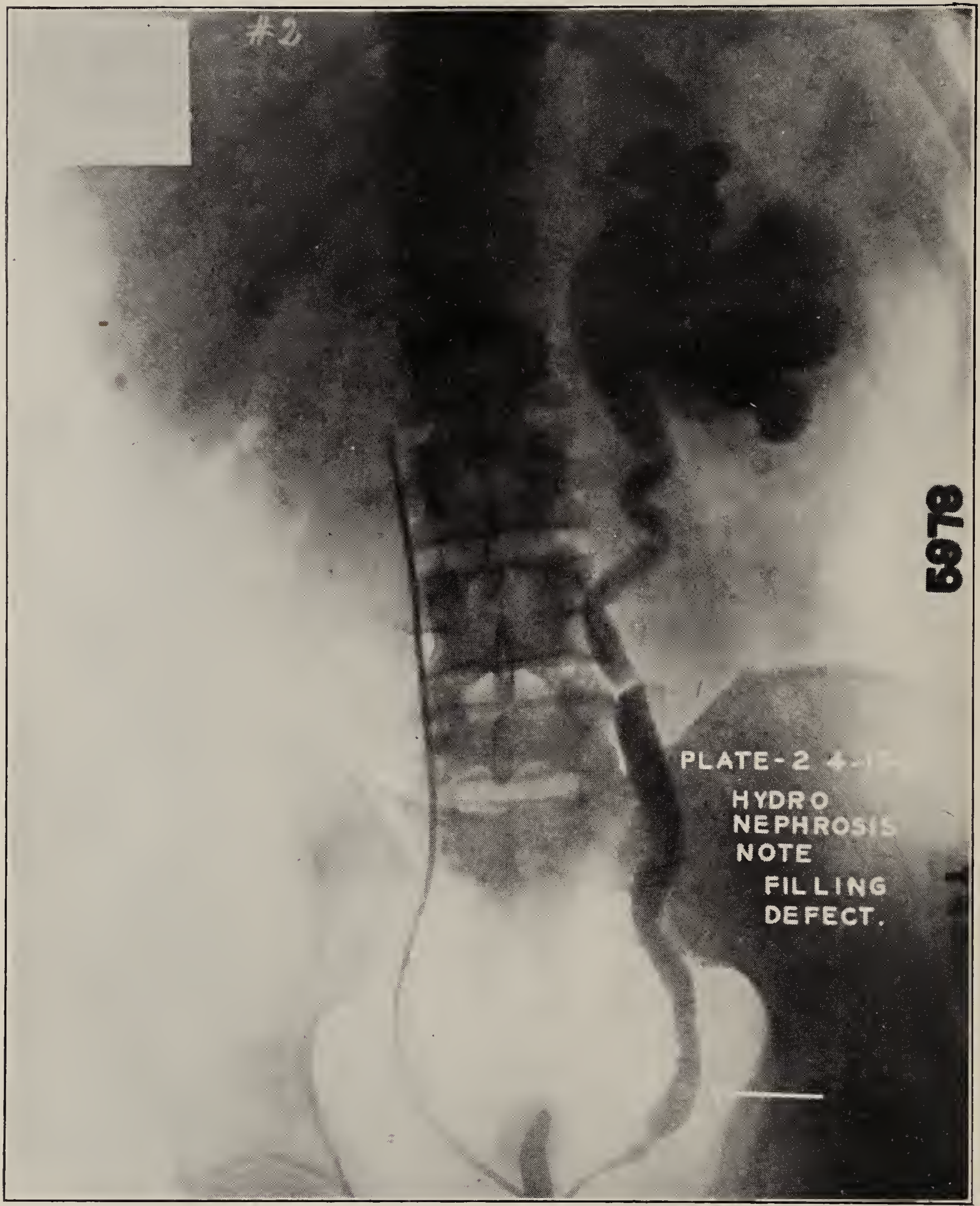


Fig. 20 shows the same patient described in Fig. 19. There is marked hydronephrosis, tortuosity of the upper ureter, stricture of the lower ureter, all in addition to the stone seen in the previous exposure. The primary change here was stricture of the lower ureter. Calculus formation and impaction in the lower ureter were later occurrences.

tion of peristalsis. It should be understood that most calculi pass through the ureter without material external assistance. Only large or irregularly shaped stones require assistance through the ureter which is normal. In the strictured or abnormally narrow ureter even small, smooth stones may need encouragement.

From an open surgical problem in the majority of cases, the management of ureter calculus has been brought into the endo-vesical surgical field by patient, intelligent use of the cystoscope and ureter catheter. In no field has conservatism made longer strides. Less than 5 per cent. of the calculi occurring in urological practice to-day require open operation.

Since anuria is usually a problem of bilateral or solitary renal disease, its causation by ureteral calculus is mentioned only in passing. Persistence of this symptom may be relieved by renal pelvic lavage through ureter catheter on the unobstructed side. If this is not tenable or fails to re-establish secretion promptly, immediate drainage by nephrostomy or pyelostomy should be carried out.

Prophylaxis is mentioned because of the greater attention accorded small stones in the kidney at the present time. The chemical side of prophylaxis consists in repeated urine analyses until reaction and predominant crystal content be established, if previous stones are not available for analysis. The reaction of the urine is then regulated to keep in solution excess salts, and the diet restricted to foods the breaking down of which results in a minimum of these end-products.

Physically, it has been demonstrated that strenuous exertion hastens the entrance of small stones into, and their passage through, the ureter to the bladder.

Intravesical manipulations are of prompt value in releasing stones impacted at the orifice or within the intramural ureter. Lowsley's rongeur is particularly well adapted to the milking of stones out of the orifice, the stone being grasped from above downward and squeezed gently while the instrument is withdrawn slightly. Unless the size of the stone is too great, one is surprised to find only faint hemorrhage into the mucosa at the site of application of the instrument.

Ureteral meatotomy is most efficient in the relief of impacted intramural calculi. The radio-therm cautery knife, offering a bloodless method of incision, is given preference over cystoscopic scissors. The upper wall of the terminal ureter is laid open by either instrument to the level of the stone. It is important that the incision be carried to the stone when possible. Failures result when a band of constricted ureter is left between the stone and the bladder. Most of these are avoidable. Attention has been drawn to the dangers attending injury of the uretero-vesical valve. Our experience has been that a clean meatotomy incision tends to re-unite in a few months sufficiently to prevent reflux.

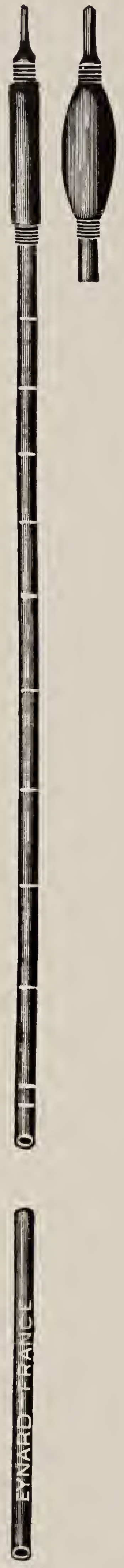


FIG. 21

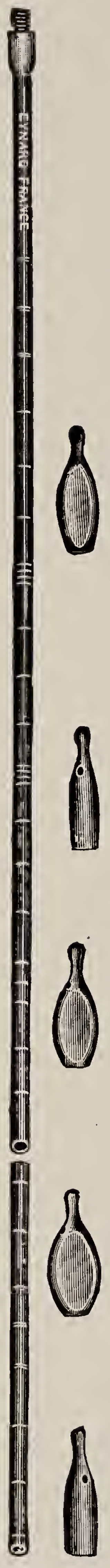


FIG. 22

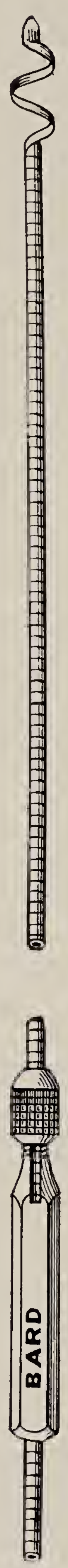


FIG. 23

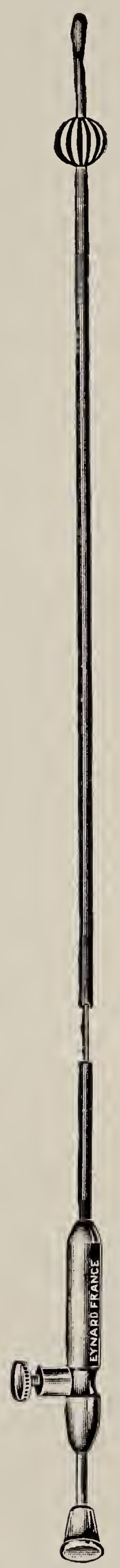


FIG. 24

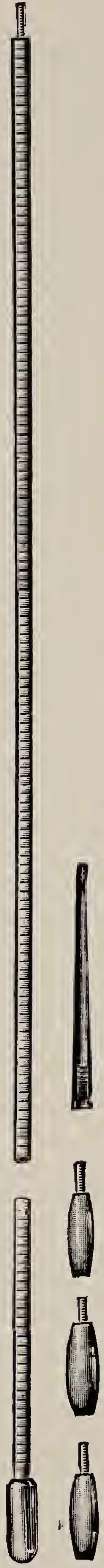


FIG. 25

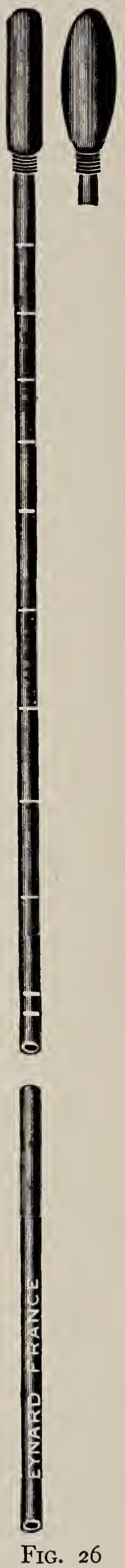


FIG. 26

[See captions on page 1004 (57)]

FIG. 21. #346-Dourmashkin Ureteral Rubber Bag Dilating Bougie, Filiform Tip. Used with 2 c/c Syringe and Adapter No. 85. (C. R. Bard, Inc., New York.)

FIG. 22. #392-Ravich Irrigating Ureteral Dilator, X-ray Catheter shaft, size 8, perforated metal bulbs, 10, 12, 14, 16, 18, larger sizes flattened to permit easy passage through operating cystoscope. (C. R. Bard, Inc., New York.)

FIG. 23. #347-Wiland Howard Spiral Stone Dislodger, with adjustable handle. Flexible Metal Shaft Size 6. Spiral Size 11. (C. R. Bard, Inc., New York.)

FIG. 24. #342-Probang Ureteral Stone Dislodger. Sizes 6 to 10. (C. R. Bard, Inc., New York.)

FIG. 25. #343-Walther Ureteral Dilator, Flexible Metal Shaft, with Filiform Tip. Interchangeable Bulbs 10, 12, 14. Additional Bulbs in sizes 16, 18, 20 made on order. (C. R. Bard, Inc., New York.)

FIG. 26. #345-Dourmashkin Ureteral Rubber Bag Dilating Bougie. Used with 2 c/c Syringe and Adapter No. 85. (C. R. Bard, Inc., New York.)

Intra-ureteral manipulations are the most commonly used aids in ureter calculus. The basis of these procedures is to increase the size of the ureter below the calculus. This is ordinarily accomplished by the passage of large-sized catheters, bulbs, or bougies as high into the ureter as possible. Our chief experience has been with the multiple bougie method through the operating Buerger cystoscope. It has been so successful that we have rarely had occasion to use the instruments necessary to permit introduction of larger ureteral bougies.

Special instruments have been devised to dilate the ureter below a stone. Others are arranged to permit dilatation above and some traction on the stone. Cradles of metal, silk, and other materials, in which the stone may be ensnared, have been signally successful in selected cases. Much caution in their use is necessary, and it is doubtful if they can ever be made as safe or as universally useful as the simple bougie which they occasionally displace.

Operation must occasionally follow our unsuccessful attempts to accomplish delivery of ureteral calculus. The surgeon must practice great restraint in dealing with these patients because of their willingness to undergo any operation which promises immediate relief. Only after every conservative method has failed should open operation be suggested.

We recognize only three indications for open operation on ureteral calculus. It will be understood that these conditions represent loss of control of a surgical situation we dare not ignore. They are: uncontrollable pain, uncontrollable fever from secondary infection, and unreasonably prolonged invalidism or semi-invalidism from repeated attacks of colic. As long as these factors are under the control of the surgeon, one is justified in maintaining conservative therapy.

The pain of impacted calculus can frequently be relieved by the passage of catheter or bougie. After a labored effort without progress, great comfort is provided by this procedure. The catheter may be left for several days and then withdrawn to permit renewal of the labor. Withdrawal is occasionally effective in bringing the stone down or even bringing it into the bladder. In certain types of patient, it is impossible to obtain cooperation for such a program, and operation must be performed. It is rare that any other reason brings to operation the patient in whom pain is the prime consideration.

Infection, manifested by chills and fever, continuous pain and exhaustion, is the most serious of the barriers to conservatism. Here, again, the indwelling catheter is a saving device. Tolerance of the patient is again the criterion by which one must be governed. The judgment of the surgeon must dictate the wisdom of delay in certain borderline cases. Necessity for more adequate drainage is the commonest cause of interference in this type.

In the last group, occasionally a patient with adequate tolerance to all the manipulations inflicted upon him may be reduced by the duration of the illness to a condition in which the surgeon feels that the lack of assurance of ultimate success after so long a period is not enough to warrant further delay. This is most exceptional.

It might be said, in summary, that the treatment of ureteral calculus is conservative as long as the patient's general health and the ultimate function of his kidney can be safeguarded.

Open operations on the ureter for stone are described under that heading at the conclusion of this section.

TUBERCULOSIS OF THE URETER

The importance of tuberculosis of the ureter to the surgeon has been increased by a number of factors. Among these are the accuracy with which diagnosis can now be made, the impression that the ureter stump, following nephrectomy, is responsible for a number of persistent sinuses, and improvement in the medical management.

From an anatomical standpoint, three types of tuberculosis are found in the ureter: primary, descending, and ascending. Clinically, an acute and a chronic type are discernible.

Tuberculosis of the ureter, in common with other urogenital tuberculosis, is probably most often secondary to pulmonary disease. Clinically, in only a minority can active tuberculosis be demonstrated outside of the urinary and genital tracts.

Hematogenous infection is not common. Where no infection is demonstrable elsewhere in the tract, and there is no contiguous tuberculous process, it may be diagnosed. Needless to say, tuberculosis of the ureter is secondary to renal tuberculosis in most instances. The organisms responsible are usually of the human type.

Pathology. The changes in the ureter brought about by tuberculosis are those one would expect. Demonstration of the primary form requires serial section of the kidney, bladder, and genital tract. One cannot say otherwise that only the ureter is involved. While no great effort has been made to establish in this way the incidence of the disease, clinically one encounters cases in which it is not possible to establish by practical means lesions elsewhere in the urogenital tract.

The descending form, which constitutes at least 85 per cent. of all ureteral tuberculosis, occurs by continuity of surface with the kidney and by constant subjection of the ureteral mucosa to tuberculous urine.

Ascending infection from the genital tract, and possibly the bladder, occurs more often than is commonly thought. In the male, epididymal, seminal vesicular, and prostatic tuberculosis is not uncommonly associated with upper urinary tuberculosis. Whether vesico-ureteral reflux is responsible or infection occurs along the postperitoneal lymphatics, 5 to 15 per cent. of upper urinary tuberculosis follows infection in the lower tract.

The ureter appears grossly as a reddened, velvety surface, studded in the acute form with pin-point to pea-sized, slightly elevated areas, somewhat yellowish in color. As the process continues, depending upon the course of the disease, the muscularis undergoes infiltration, its elasticity is lost, and dilatation occurs. In the acute form submucous infiltration occurs more rapidly. In the chronic form this process goes on at such a slow pace that contraction has time to occur and stricture is common.

Microscopically there is a thickening of the mucous membrane, tubercle formation, and fibroblastic proliferation in the mucosa and muscularis.

Associated pathology includes the primary pulmonary, renal, and genital foci. Bladder infection is practically always from the kidney.

Diagnosis is based upon a history of tuberculosis of the kidney or genitals together with the signs of urinary tuberculosis. It can only be confirmed by cystoscopic and x-ray studies.

Cystoscopy. If the history and findings prior to cystoscopy have not suggested tuberculosis of the urinary tract, one's first impression of the bladder, after introduction of the cystoscope, is apt to do so. The appearance of a tuberculous bladder, elsewhere detailed, warns the operator of the wisdom of antiseptic bladder lavage before ureteral catheterization. Trabeculation of the bladder may be noted. The presence of ulceration about the ureteral orifice is suggestive. Typically the ureteral orifice is gaping and, because of the ureteral shortening, the bladder wall immediately surrounding the orifice is retracted upward and backward, making it patulous. Urine ejected from the orifice may or may not be turbid. Its frequency may be retarded and its force diminished. Attempts to find the orifices in extensive vesical tuberculosis are not uniformly successful. The intravenous administration of 5–10 cc. of indigo-carmin usually facilitates their demonstration. Difficulty in catheterization is due to stricture or tortuosity. If one is able to pass a catheter far enough into the ureter to permit pyelo-ureteral injection, a record of the changes may be made. Cystography, when catheterization fails, not infrequently demonstrates a vesico-ureteral reflux which shows the ureter in detail.

Routinely, the catheter is passed to the kidney pelvis and, following collection of such specimens as are needed, pyelogram in the prone and ureterogram in the erect posture are carried out. The wisdom of ureterography on one side only at a sitting is particularly applicable in tuberculosis. Fear, which some surgeons have, of ureteral catheterization and pyelo-ureterography in tuberculosis, has not been justified in our experience. In miliary tuberculosis, of which the first symptoms are urinary, catheterization is usually contraindicated. In no other instance have we seen complete cystoscopic and urographic study of urinary tuberculosis followed by untoward results not equally prevalent in non-tuberculous infections.

X-ray. The diagnosis of ureteral tuberculosis is verified by urography. Occasionally there is sufficient calcification of the ureter to portray its outline in a plain film. More frequently, after catheters have been passed to both kidney pelves, a plate taken to show their position will reveal on the diseased side a straightened ureter taking the shortest path from kidney to bladder, contrasting with the curvature of the normal side.

The pyelogram which precedes injection of the ureter will usually show evidence of tuberculosis of the kidney. The ureterogram may take one of two forms. In acute upper urinary tuberculosis the ureter is seen as a contracted tube with faint irregularities at its circumference. Such a ureterogram, coupled with a pyelogram of tuberculosis, is absolutely diagnostic. The chronic form is characterized by a dilated ureter with

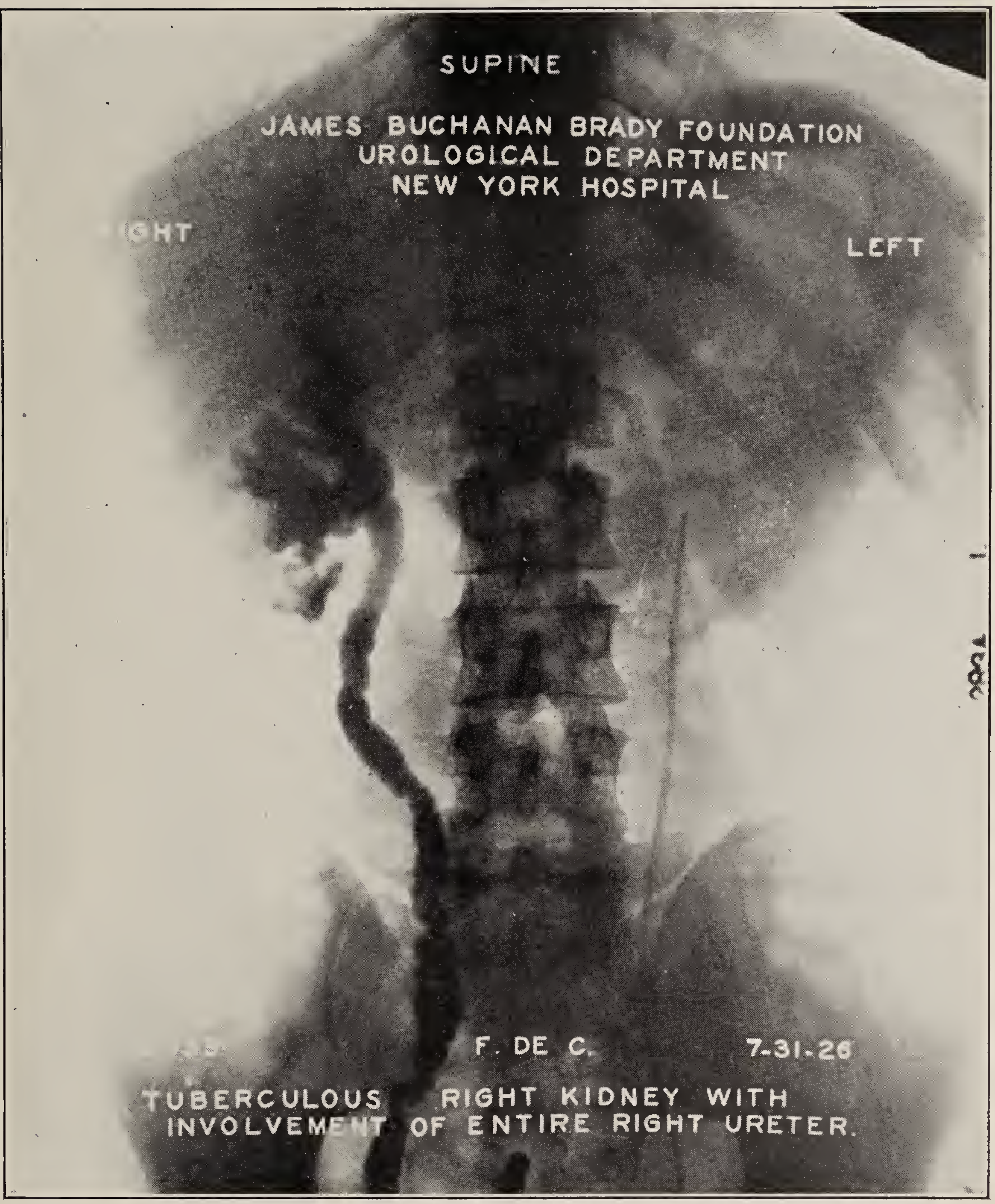
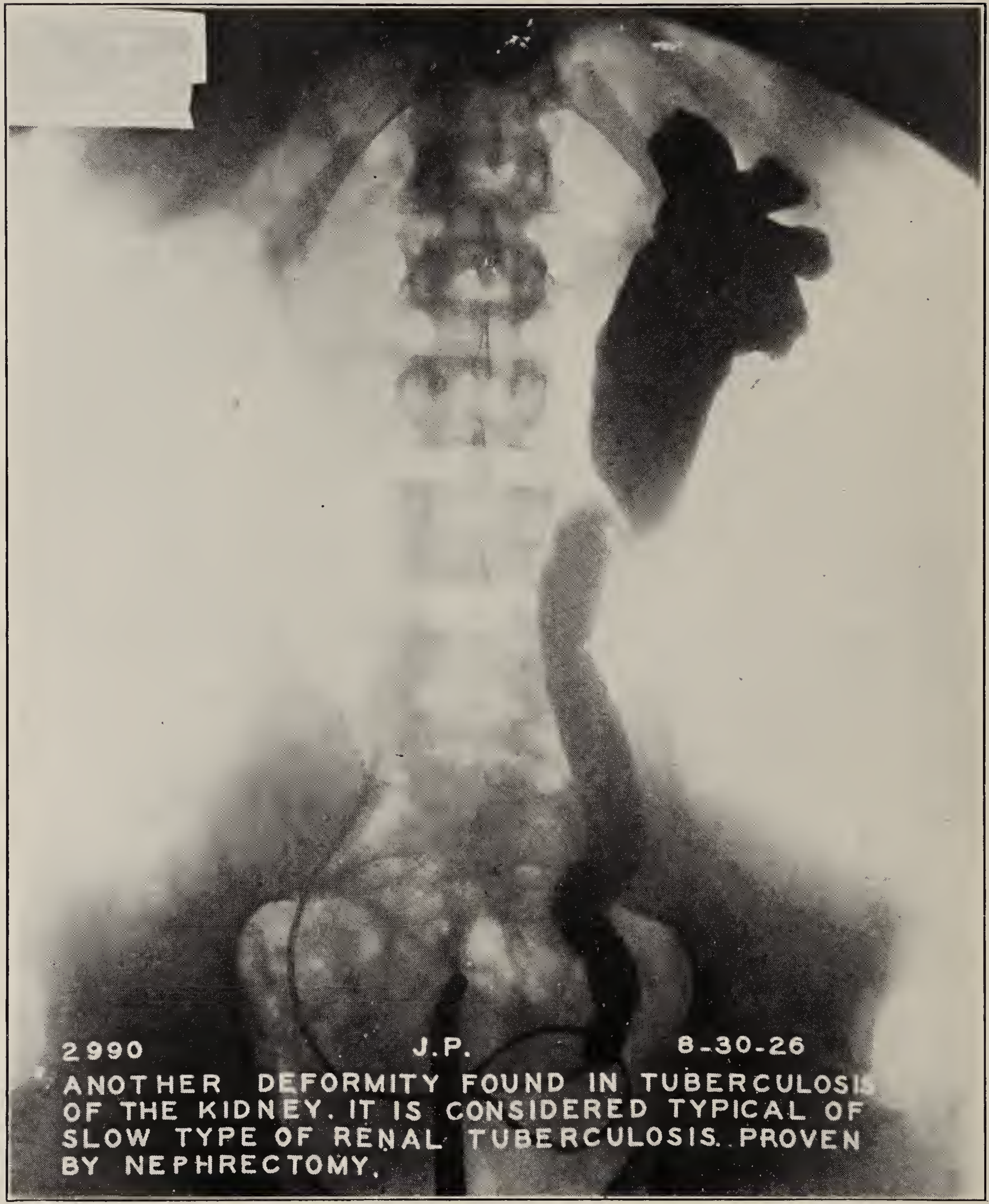

SUPINE
JAMES BUCHANAN BRADY FOUNDATION
UROLOGICAL DEPARTMENT
NEW YORK HOSPITAL
GHT
LEFT
F. DE C.
7-31-26
TUBERCULOUS RIGHT KIDNEY WITH
INVOLVEMENT OF ENTIRE RIGHT URETER.

FIG. 27 shows marked hydronephrosis, hydro-ureter and stricture of the ureter, all of tuberculous origin. The chronicity of these changes is implied by the obvious time required for such marked extensive dilatation.

or without stricture, as shown by ureterogram. Faint irregularities of the periphery of the ureter comparable to those seen in the calyces are demonstrable. This shaggy appearance of the mucosal surface of the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ANOTHER DEFORMITY FOUND IN TUBERCULOSIS OF THE KIDNEY. IT IS CONSIDERED TYPICAL OF SLOW TYPE OF RENAL TUBERCULOSIS. PROVEN BY NEPHRECTOMY.

Fig. 28. This shows the opposite type of renal and ureteral tuberculosis. The process has developed so rapidly here that neither definite stricture formation nor dilatation of the ureter has had time to occur. Note the beaded appearance of the ureter. Shaggy periphery is not as well shown here as in the original film.

ureter, as outlined by the dye, is quite as diagnostic of ureteral as renal tuberculosis.

Treatment. Ureteral tuberculosis, from the standpoint of treatment, may be divided into three groups: renal and ureteral infections which are treated by nephro-ureterectomy; post-nephrectomy ureteral stump; and inoperable nephro-ureteral tuberculosis.

Of the first group, little need be said. The radical excision of the entire ureter has been recommended widely when a definite clinical and operative diagnosis of ureteral involvement is made.

In the second and third groups there is a growing belief in the potency of hygienic and conservative therapy. The success which has attended such measures in a high percentage of cases has led to their uniform trial before secondary surgery is advised. Of even greater importance is this conservatism in doubtful cases. It has been suggested that many persistent post-nephrectomy sinuses are due to the infected pedicles and peri-renal structures rather than the condition of the lower end of the ureter. Under no circumstance should radical removal be advised if there be this doubt.

The conservative management includes local care of the loin sinus which persists. Frequent carbolization of the granulations, exposure of the sinus to air, sunlight, and ultra-violet therapy, are important in this connection. There is no illusion concerning the rationale of direct exposure of the wound to sunlight. It is generally conceded that the virtue of this latter measure lies in its general tonic influence rather than in any direct local influence. Instruction to these patients concerning the value of salt-water bathing, preferably at the beach when combined with natural or artificial ultra-violet irradiation, constitutes an important advance.

Of equal importance, and of longer approved standing, is high caloric diet with frequent feedings, enforced rest, and measures to increase weight and promote general health. Cod-liver oil and irradiated olive oil are valuable. Methylene blue by mouth is effective in lessening the vesical irritability of which these patients complain.

Old Tuberculin. The administration of tuberculin is a task requiring thorough knowledge of the disease. It should be given only by experts to patients in whom the absence or degree of pulmonary tuberculosis has been ascertained. The exact dosage must be individualized. By reaction obtained to very small doses, the value of the drug may be estimated and dosage computed for the individual. In some cases, the severity of reaction to a minimal dose precludes its use.

Cystoscopic Treatment. The lower end of the ureter left at nephrectomy may become secondarily infected and require gentle dilatation and lavage through a ureteral catheter. It may be added that in any secondary infection, particularly in inoperable renal tuberculosis, gentle dilatation of the ureter and pelvic lavage are of great benefit. Much discrimination must be used in the choice of patients who will benefit from this therapy.

Secondary Ureterectomy is indicated in two types of ureteral tuberculosis: first, those in which the patulous ureter makes possible a urinary sinus draining from the bladder into the loin; and, second, sinuses which do not heal because of persistent ureteral infection.

Urinary fistula following nephrectomy demands ureterectomy as soon as the patient's general condition warrants.

Ureterectomy for persistent non-urinary sinus should be postponed until the patient's general condition is satisfactory, all conservative measures have been tried faithfully, and both surgeon and patient are convinced that return to useful life can be accomplished only after this operation.

Prognosis is dependent upon the degree of ureter and bladder involvement. Extension into the postperitoneal tissue, when due to the ureter infection, may well deserve secondary surgery.

SYPHILIS OF THE URETER

The incidence of syphilis in the ureter is probably greater than we suspect. Obscure urinary symptoms which are common in the first and second stages of the disease may well be of ureteral origin. Vesical lesions are occasionally noted at cystoscopy. In the toxemia of acute early syphilis it is probable that changes could be demonstrated in the mucosa of the ureter comparable to those seen in other mucous membranes.

Stricture of the ureter was attributed to syphilis by early observers. The wisdom of routine serological examination as a part of every urological survey would seem to be apparent.

CORD LESIONS

Cord lesions of infectious origin, or those following trauma, play an interesting rôle in the ureter. Of more didactic than practical interest, many of the dilatations of the ureter for which no mechanical cause may be given, are of this origin. Doubtless, in the incipient stages we overlook these lesions very often. Treatment is directed to the etiologic process when this is feasible. Unless there be renal infection, instrumentation is contraindicated because of the lack of resistance in general which characterizes these patients.

BILHARZIASIS

This disease is quite prevalent in Egypt, Arabia, and their environs. In conjunction with bladder and kidney involvement, which occurs through the blood vessels, the ureter may become diseased. Hematuria, frequency, and urgency occurring in immigrants from infested countries, should arouse suspicion as to possible Bilharzia, and the urine carefully searched for ova. Ureteral involvement necessitates nephro-ureterectomy.

URETERITIS CYSTICA

This is a disorder of the ureter characterized by multiple, minute inclusion cysts varying in size from a pin-head to a split pea, and in number from several to hundreds. Associated with them, a like change in the kidney and bladder is frequent.

The presence of this condition, noted at operation and autopsy on numerous occasions, has been suspected by surgeons at cystoscopy when bleeding, obstruction, or irritative renal symptoms have not been explicable otherwise.

There is some doubt as to its exact nature. In many specimens, simple inclusion cysts, containing straw-colored fluid without evidence of infection in the mucosa, have been found. Such findings have been interpreted as suggestive of neoplasm probably arising from embryonal rests.

Other observers have found the mucosa and subjacent structures studded with round cells and have noted association with other urinary infections, particularly in the upper tract. To this group the process is inflammatory.

Diagnosis is based upon the cystoscopic finding of cysts in the bladder and protruding from the lower ureter. Ureteral catheterization may be impossible or may be accomplished with difficulty and considerable hemorrhage. To date, uretero-pyelographic study has been disappointing. Rarely has x-ray evidence of value been obtained.

Treatment is conservative in those cases in which symptoms do not persist and in which the diagnosis can be fairly accurate. If hematuria or pain persist, removal of the kidney and ureter must be considered. Demonstration of normal kidney function and the absence of renal bleeding, as shown by clear urine from the renal pelvis, suggest the possibility of resection of the ureter, when only the lower end is diseased. Pyelostomy or nephrostomy might be chosen rather than nephrectomy in patients with no renal reserve.

Prognosis as far as life is concerned is good. Danger from hemorrhage is slight, the persistence of upper urinary obstruction being the chief cause of trouble. No evidence has been found that these cystic processes undergo malignant degeneration.

LEUCOPLAKIA OF THE URETER

This is a disease of comparative rarity characterized by areas of whitish thickening of the mucosa which, upon section, are found to resemble, in the stratification of epithelium, the outer layers of the skin.

Etiology is not known, but the association of the condition with chronic infectious processes suggests its origin. By some it is considered a pre-epitheliomatous lesion, histologically.

Recognition other than at autopsy is almost impossible. Associated vesical lesions of this type are suggestive when there is ureteral obstruction.

TUMORS OF THE URETER

Primary tumor of the ureter is of very rare occurrence. It may be benign, but is usually malignant. Fibroma, papilloma, and carcinoma occur.

Secondary involvement of the ureter occurs most often at the vesical end as a result of prostatic, vesical, and uterine malignancy. Papillary carcinoma of the kidney is prone to metastasize to the ureter and bladder. Extension occurs by blood and lymphatic metastases to the neighboring glands, lungs, et cetera.

Clinical course in these neoplasms depends upon their duration and location. In the upper ureter evidence of obstruction is most prompt and pain acute. At the lower end extensive processes develop with but little evidence referable to the ureter.

The type of malignancy is of less significance in the course than the position. It is usually the evidence of occlusion of the ureter which attracts attention. The degree of infection which coexists plays an important rôle in the clinical course. In the absence of infection, it is possible for extensive changes to proceed without great discomfort.

Diagnosis is made at cystoscopy, operation, and at autopsy. History is never diagnostic. Hematuria is the first evidence. Obstructive symptoms follow rapidly if it be at the upper end, more tardily if at the lower end. The passage of clots down the ureter may simulate colic of calculus origin.

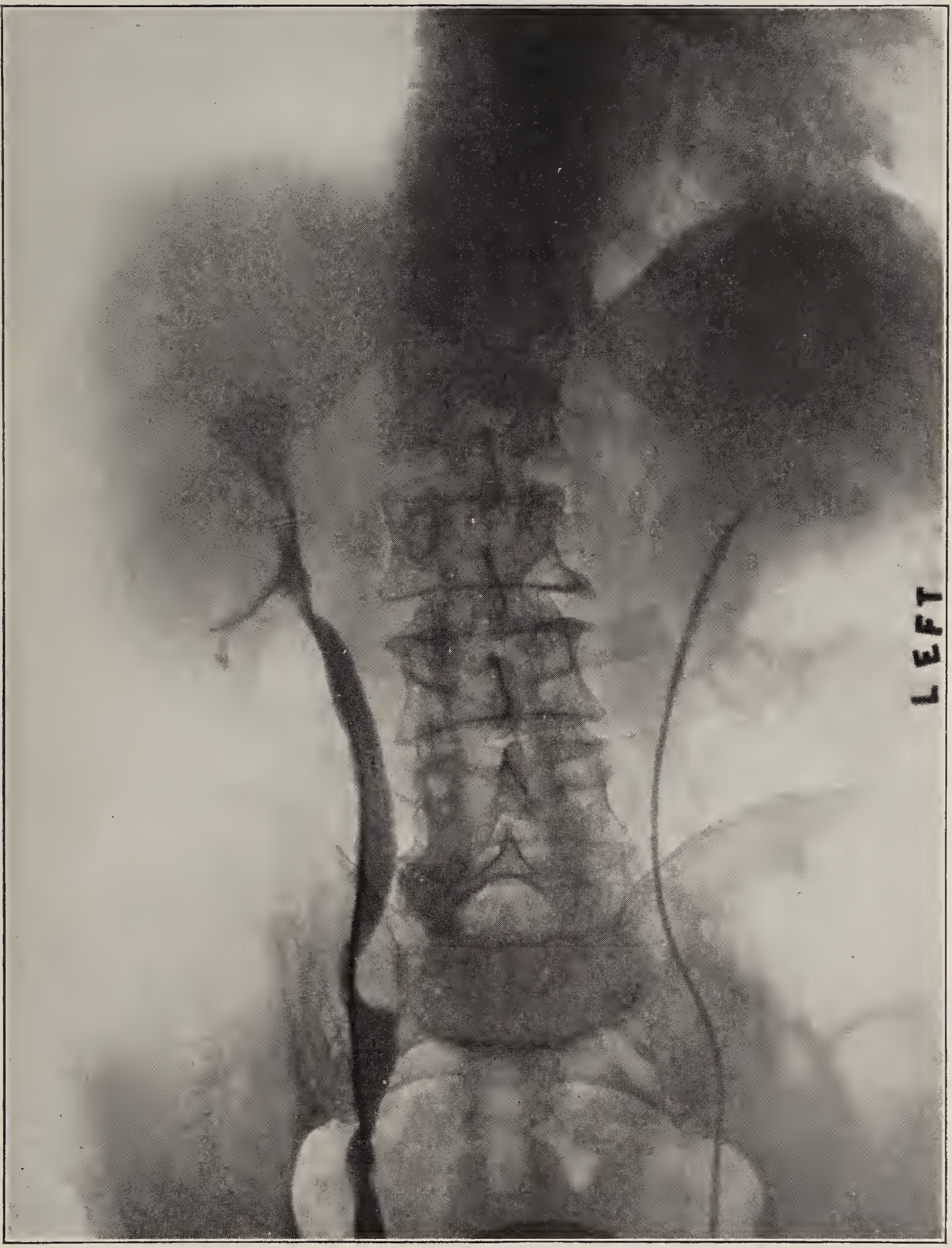

FIG. 29. This shows a definite tumor of the right kidney together with a deformity low in the mid-ureter.

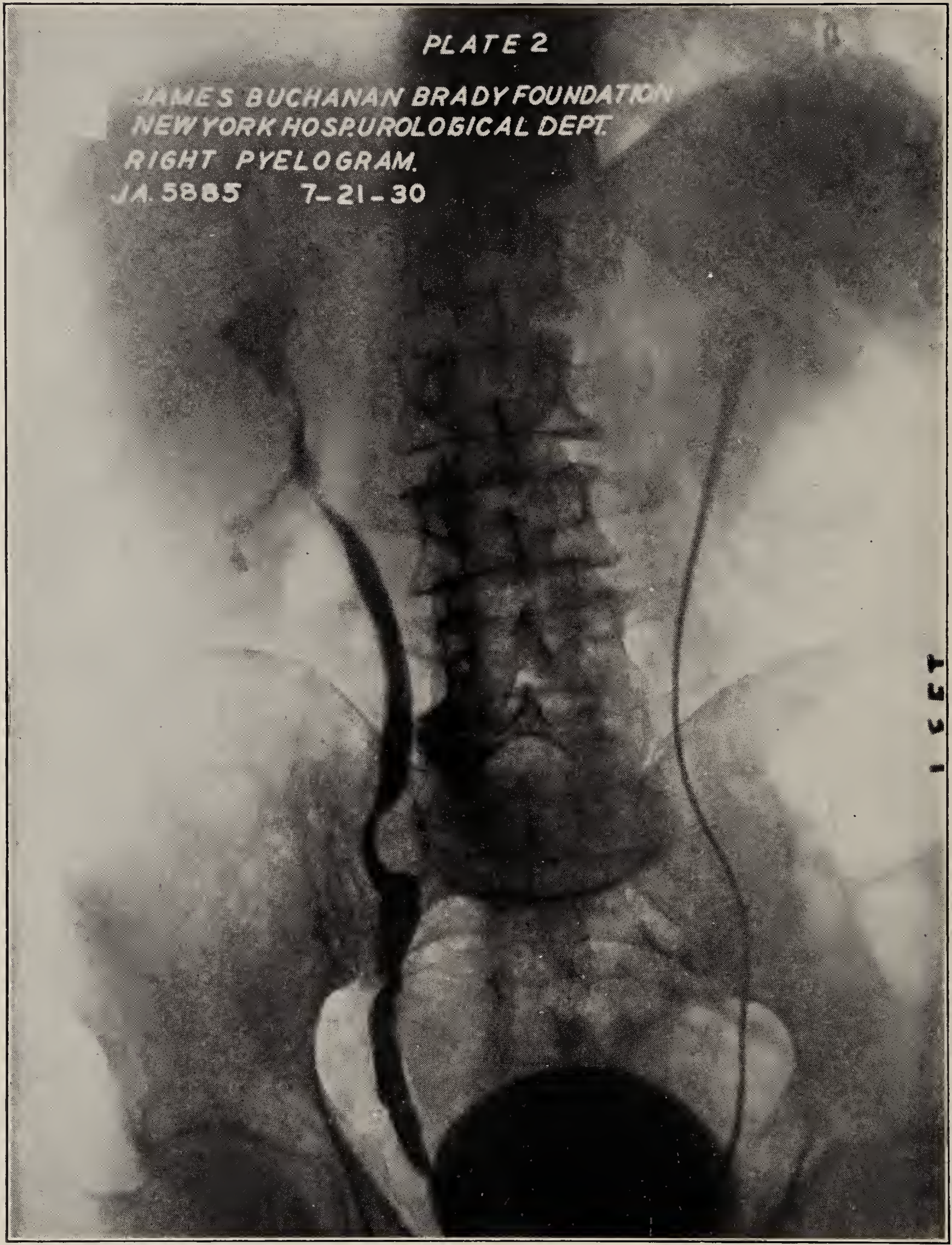
PLATE 2
JAMES BUCHANAN BRADY FOUNDATION
NEW YORK HOSP. UROLOGICAL DEPT.
RIGHT PYELOGRAM.
JA. 5885 7-21-30
LEFT

FIG. 30. Here the catheter has been withdrawn to demonstrate the reality of the deformity noted in the previous plate. Tumors of kidney and ureter were found at operation.

Only the length of the clots suggests upper urinary disorder. If infection is added, symptoms are focused at the kidney rather than the ureter.

Cystoscopically one may see tumor projecting from the end of the ureter through the ureteral orifice. There may be gross hematuria from one ureter associated with papillomatous tumor or tumors in the bladder. Passage of ureter catheter may be obstructed or it may occasion hemorrhage around the catheter into the bladder, the while clear urine escapes from the pelvis of the kidney through the catheter.

Urography is seldom diagnostic. An obstruction may be shown. There is otherwise little to be learned by x-ray unless pyelography reveals tumor.

Treatment is surgical removal. When only the lower ureter is involved, it may be possible to reimplant the upper segment into the bladder or bowel. Usually nephro-ureterectomy must be performed.

Prognosis is always grave. The association of neoplasm with renal damage provides a grave outlook. Prompt surgery has been rewarded with complete freedom from symptoms and occasionally an apparent cure. Benign tumors have, of course, a more hopeful outlook.

DIAGNOSIS OF CHANGES IN THE URETER

The recognition of ureteral changes, as apart from changes in the kidney and bladder, is of recent origin. So passive was the ureter considered in the function of the urinary tract that brief consideration was given diagnosis of its disorders, as has been shown in the foregoing pages. Changes in the ureter are usually associated with renal or vesical disease. It is quite possible, however, to dissociate the ureter entirely and to establish priority of change within this structure in many instances.

History Taking is of importance in acquiring presumptive evidence of ureteral disease. Frequently the outstanding symptoms are those referable to associated renal or vesical disease. In the group, however, which is characterized by absence of suggestive findings or by only slight pyuria with marked urinary frequency, a careful history will often suggest ureter as the focus. The outstanding symptom may be frequency of urination or abdominal pain. These may be associated with each other. Often urinary frequency attracts sufficient attention to the urinary tract to bring the patient under observation promptly. Too frequently, however, the absence of abnormal urinary findings condemns to a period of futile oral and mental therapy. Certainly the presence of increased leucocytes or of erythrocytes in the urine should demand prompt urological survey.

Abdominal pain of ureteral origin is difficult to describe. It is the essence of discomforts to which the abdomen is subject, resembling at some time or other every intra-abdominal lesion. It is the lack of character which suggests ureteral disturbance. Described by some as recurrent mild cramp-like distress in mid-abdomen, usually unilateral, remaining localized or radiating to the back or genitals, it has been responsible for many unfortunate labels of gall-bladder disease. The association of anorexia, nausea, or mild obstipation has been responsible for its designation as chronic appendicular disease or, more rarely, gastric or duodenal ulcer. In those cases in which urinary frequency is the prominent symptom, the abdominal pain, particularly in the female, is attributed to internal genital change, gross evidence of which may or may not be demonstrable.

The frequency with which patients with ureteral obstruction of varying degrees give a history of one or more abdominal operations makes a record of previous surgical experience an important item in diagnosis.

In summarizing, the history in ureteral change is of greatest value in spite of its resemblance to so many other conditions.

Physical Examination is of greatest value when it fails to reveal any definite evidence of genital or abdominal disease. One or more laparotomy scars are frequently the only positive findings. The examination should be thorough enough to locate possible sources of infection in the dental and oral structures as well as the establishing of freedom from venereal or quasi-venereal disorders.

Tenderness along the course of the ureter, most prominent where this structure passes over the bony pelvis, has been considered of diagnostic value. Vaginal examination is very useful in the detection of tenderness along the course of the pelvic ureter, presence of stone as well as inflammatory or neoplastic changes in the adnexæ related to the ureter. Rectal examination in the male may on occasion reveal seminal vesicle disease affecting the ureter, or calculus in the lower ureter.

Laboratory Examination includes blood and urine study. No specific changes in the blood occur from ureteral disorder. In changes of neoplastic character anemia will be found. Infections produce a leucocytic response resembling that seen in other viscera. A more perfect drainage of this structure, however, tends to restrict leucocytosis. Blood chemistry may reveal elevation of nitrogenous elements if there be allied renal change.

Study of the urine is important. Here, again, the lack of findings may be highly suggestive in the presence of urinary frequency and symptoms of urinary change. Characteristically, only a slight increase in the number of unclumped white cells or a few small clumps of white cells are found. Occasionally red blood cells are due to an ulcerative process in the ureter. Manifestly, large amounts of pus, blood, or albumen bespeak vesical or renal rather than ureteral disorder.

It has been said that a careful history, a searching physical examination, and urine analysis should be sufficient to diagnose with fair accuracy four-fifths of all ureteral changes. We must rely upon cystoscopy, however, for confirmation and therapy.

Cystoscopic Examination. There are no contraindications to cystoscopy in primary ureteral disorders. Even nephritic patients, with definite change in vascular tension and renal function, may be subjected to careful cystoscopy if the need arises.

The indications for cystoscopy to determine the presence and degree of ureteral change include abdominal, loin, or vesical distress of unproved origin in the presence or absence of urinary findings.

Cystoscopy having been decided upon, the instrument most commonly used is the Brown-Buerger catheterizing cystoscope. In the female, many procedures in endo-vesical ureteral surgery are facilitated by the use of the Kelly cystoscope. The catheters, bougies, bulbs, and various instruments used vary with the operator. In some clinics it is customary to explore every cystoscopic patient for ureteral obstruction with bulbs, as in urethral examination.

Upon introduction of the cystoscope into the bladder, the type of catheterized bladder urine is noted. Clarity of urine usually rules out gross infection or neoplastic change. Turbid or bloody urine indicates more advanced change. The necessity for prolonged irrigation before being able to visualize the interior of the bladder gives one an idea of the degree of infection present. The appearance of the bladder injected acutely, sub-acutely, diffusely, or in localized areas, is of value in preparing the operator for the type of change to be expected. Ulceration in or about the ureteral orifice, papillary new-growth, particularly of the multiple type, and calculus in the bladder, all suggest the possibility of ureteral disturbance of a corresponding type. The appearance of the ureteral orifice, whether gaping with the typical golf-hole appearance of chronic inflammation, or of the pin-hole type associated with ureterocele, is diagnostic. The function of the ureters and kidneys, as determined by the frequency and force with which urine is emitted, are of importance in the study.

The interior of the bladder having been carefully studied and the presence of all changes noted, the operator is now ready to study the ureter.

Ureteral Instrumentation. Ureteral instrumentation is essential for several reasons. Its important functions are to demonstrate the patency of the ureter and to collect specimens for study. The use of the bulb is to detect, appraise, and dilate narrowings of the ureter. Variations of the bulb principle are employed in the detection of ureteral calculi.

As elsewhere in the urinary tract, the greatest gentleness is imperative in instrumental manipulation. Catheters should be inspected before use for surface cracks; the tips between the eyes noted for breaks which slight traction might sever; and their patency determined before placing them in the cystoscope. When wax bulbs are used, one may keep an assortment of sizes or prepare the size desired after estimating the size of the ureteral orifice.

It is our routine with adults to pass #6 F. lead catheters to the kidney pelves, noting any obstruction or difficulty encountered. Should there be obstruction to this size, smaller ones are used. If stricture of the ureter or other obstruction is suspected, the ureter is explored at the first examination, or at the subsequent sitting, with bulbs, to determine the size and location of narrowings. The use of calibrated catheters and bougies facilitates location of obstruction.

It is possible in a great many cases, by the detection of obstruction or by the finding of hydronephrosis or stone, to diagnose accurately by instrumental study alone the condition of the ureter. No such examination is adequate for routine use. Large caliber strictures may be overlooked by this method. An x-ray study should always supplement instrumental examination.

X-ray Study of the Ureter. For a considerable period after injection of the renal pelvis with opaque substances had become fairly commonplace, the ureter remained obscure from an x-ray standpoint. In some of the earlier pyelograms the ureter was completely outlined by an overflow of dye from the pelvis. The inconstancy with which the ureter was visualized led gradually to withdrawal of the catheter and injection of the ureter. In most clinics it is now customary to do ureterograms routinely on the basis that any upper urinary disorder warranting cystoscopy can only be adequately studied by visualizing the entire tract.

Indications for visualization of the ureter are many. Perhaps it would be better to state that no contraindication has been advanced in patients upon whom pyelography is justifiable. It should be said that ureterography is imperatively indicated in every obscure renal, abdominal, sacro-iliac, and internal genital involvement before radical or exploratory operation upon these parts is considered. Emphasis is here placed on the obscure nature of such disorders because of the number of patients who appear after repeated open surgical efforts have been expended without relief. Careful perusal of the preliminary study carried out in these patients always impresses one with a lack of definition of data upon which operation was performed.

Contraindications to ureterography are few. The most important is urogenital infection when a part of miliary tuberculosis. A second obtains in the cystoscopy at which no urinary drainage occurs from a patent catheter, passage of which is obstructed particularly in the lower ureter. A few drops of bloody fluid may indicate perforation of the ureter and hence injection is done only at the risk of infiltrating the peri-ureteral tissues with dye. Inasmuch as this is usually not a serious complication, the urgency of the information sought will dictate procedure under these circumstances. Tuberculosis of the kidney, which is fairly definite clinically and cystoscopically before ureteral catheterization has been performed, does not contraindicate pyelo-ureterography in our experience. Occasionally the insertion of a catheter into the kidney pelvis of a patient acutely ill is followed by the release of fluid under pressure. It is wise in such cases to postpone ureterography as well as pyelography until drainage has been established for a period sufficient to permit recovery from infection.

A technique, to be consistently useful in the study of the ureter by x-ray, should include a routine elastic enough to cover such unusual situations as arise but uniform enough to permit intelligent comparison at all times.

X-ray examination before insertion of ureteral catheters is distinctly informative at times. In an age which stresses the economic side of all phases of the practice of medicine and surgery, routine inclusion of such a procedure must be frowned upon. One is occasionally surprised in the examination of such a film to see calcification of the ureter sufficiently intense to visualize this structure in part. Shadows of stone or calcified lymph glands and phleboliths may be noted. The misinterpretation of the absence of shadows in these films as absence of disease is perhaps the greatest objection offered.

X-ray catheter having been passed to the kidney pelvis, pyelography having been performed, it is our custom routinely to elevate the head of the table to such an extent that the patient is practically erect before beginning injection of the ureter. The advantage of this procedure is to contrast the position of the kidney and ureter in the prone and erect positions. As soon as the patient complains of pain, the catheter is gradually withdrawn from the pelvis into the ureter, the injection continuing until the tip of the catheter is released by the ureter when the exposure is made.

In certain cases ureteral orifices are so obviously patulous reflux can be predicted before exposure. In others, attempts to distend pelvis and ureter result in a cystogram only. It is impractical to follow the usual technique under such circumstances. Here ureterography may be carried out successfully by lowering the head of the table after occluding the ureteral orifice with a large catheter through which injection is made. Should the opening be too large, it is best to distend the bladder with a solution of dye one-fourth the concentration employed for pyelography, and allow the dye to flow upward. This method is particularly applicable in extensive vesical tuberculosis which prohibits ureteral catheterization. One is often surprised, after an effort which exhausts the tolerance of the patient, to see the success of this reflux cysto-uretero-pyelography.

Intravenous Ureterography (Uroselectan, Skiodan, Iopax, et cetera). The ureterograms obtained by intravenous iodide preparations of the Uroselectan type have added interest in ureteral surgery. The novelty of the method, the frequent necessity for comparing findings with those obtained by the retrograde method, and the exorbitant cost of the dual procedure, all tend to detract from its value at present.

Sufficient experience with the method has accumulated, however, to assure it a permanent place in urological practice as an adjunct, frequently, and an adequate substitute, occasionally, for retrograde pyelo-ureterography. The best intravenous urograms are obtained in gross obstructions. Tortuosity, anomalies, and dilatations are frequently well shown. As soon as the cost of the drug and the number of essential x-rays have been minimized, we anticipate widest possible use of this new method.

TREATMENT OF URETERAL CHANGES

We may classify treatment as cystoscopic, general, and open operative. In the preceding pages cystoscopic management of the various entities has been largely detailed because of its prominence in ureteral surgery. It has forced into relatively minor positions both general and operative methods.

Much depends upon the general condition of the patient in outlining the management of ureteral disorders. Acute inflammatory conditions, associated with constitutional disturbances, require general care in addition to whatever local therapy seems indicated. Ingestion of large quantities of fluid and acidulation or alkalization of the urine are most essential in this type of disorder. Urinary antiseptics are efficient in concentrated urine. It is doubtful if they are valuable enough to warrant restriction of fluids. Urotropin has had the widest use of any urinary antiseptic. The urine having been acidulated with sodium acid phosphate, sodium benzoate, or dilute acids, doses of five to fifteen grains at three- to six-hour intervals have been found most efficient. The intravenous use of this drug has met with considerable success in some clinics.

Hexylresorcinol has been in use sufficiently long to establish its value in infections of the coccus group. More recently a group of antiseptics synthesized from the pyridines has been used and approved. Results have been encouraging enough to permit wide distribution and to improve definitely our equipment in combating infection in the urinary tract. In the treatment of ureteral inflammatory conditions, it has been so thoroughly demonstrated that drainage is the important factor, urinary antiseptics should be an adjunct rather than a basis of therapy.

In changes of few structures must sedatives be used as largely as in the ureter. Sedation of the urinary tract is accomplished by bland aromatics of the santal oil type, and by anti-spasmodics of the belladonna group. The use of hyoscyamus with an alkali has become almost universal in the milder ureteral colics. Atropine with morphine is the foundation for relief from a pharmacologic standpoint, and the tolerance of patients with colic is well known. In severe pain the wisdom of full doses of both morphine and atropine is manifest. Atropine in doses of gr. 1/100 has a potent action in relaxing spasm when combined with morphine gr. $\frac{1}{4}$ to $\frac{1}{2}$.

The dietary permitted in ureteral changes is variable. The large amount of fluids prescribed frequently diminishes the appetite and necessitates including in a liquid or soft diet such articles as are essential to the maintenance of nutrition. For this purpose, cereals, fruit juices and milk drinks are widely used. A meat-free diet is routine in most institutions. In some a salt-free, meat-free diet is prescribed.

OPEN OPERATIONS ON THE URETER

Open operations may be divided into three groups: those performed upon the upper, middle, and lower ureter. The following approaches may be visualized more readily if considered as integral parts of a single incision beginning at the costovertebral angle and extending mesially downward and forward over the iliac crest toward the symphysis. Overlapping of incisions is the rule in any given series of operations.

In the order of frequency of performance the following list will be described: ureterotomy, ureterostomy, ureterectomy, and ureterorrhaphy.

Exposure of the upper ureter is similar to that of the kidney. The lumbar extraperitoneal route is always chosen. The position for kidney exposure is assumed. There are numerous incisions, but that most useful in our hands is the S-shaped, starting at the costovertebral angle one-half to three-fourths of an inch from the spine and twelfth rib, extending downward and anteriorly toward the anterior superior spine, keeping one to one and one-half inches above the crest of the ileum. The last inch or two is given a slightly downward direction toward the pubic spine. Fat and fascia are separated down to the latissimus dorsi, oblique and transversus abdomenis muscles. Petit's triangle is entered, and the peritoneum peeled anteriorly from the muscles and fascia. The two oblique and transversus abdomenis muscles are incised, exposing the anterior lumbar fascia, quadratus lumborum muscles, ilio-inguinal and ilio-hypogastric nerves and vessels, which should be carefully guarded. The fascia is opened, revealing the yellow peri-renal fat beneath which the kidney may be palpated. After the lower pole of the kidney has been freed, the ureter may be found usually on its postero-mesial aspect. If not here, it is just distal to this region, adherent to the peritoneum from which it can be readily peeled and examined. It is best to place a piece of cotton tape about the ureter to fix its position in the wound.

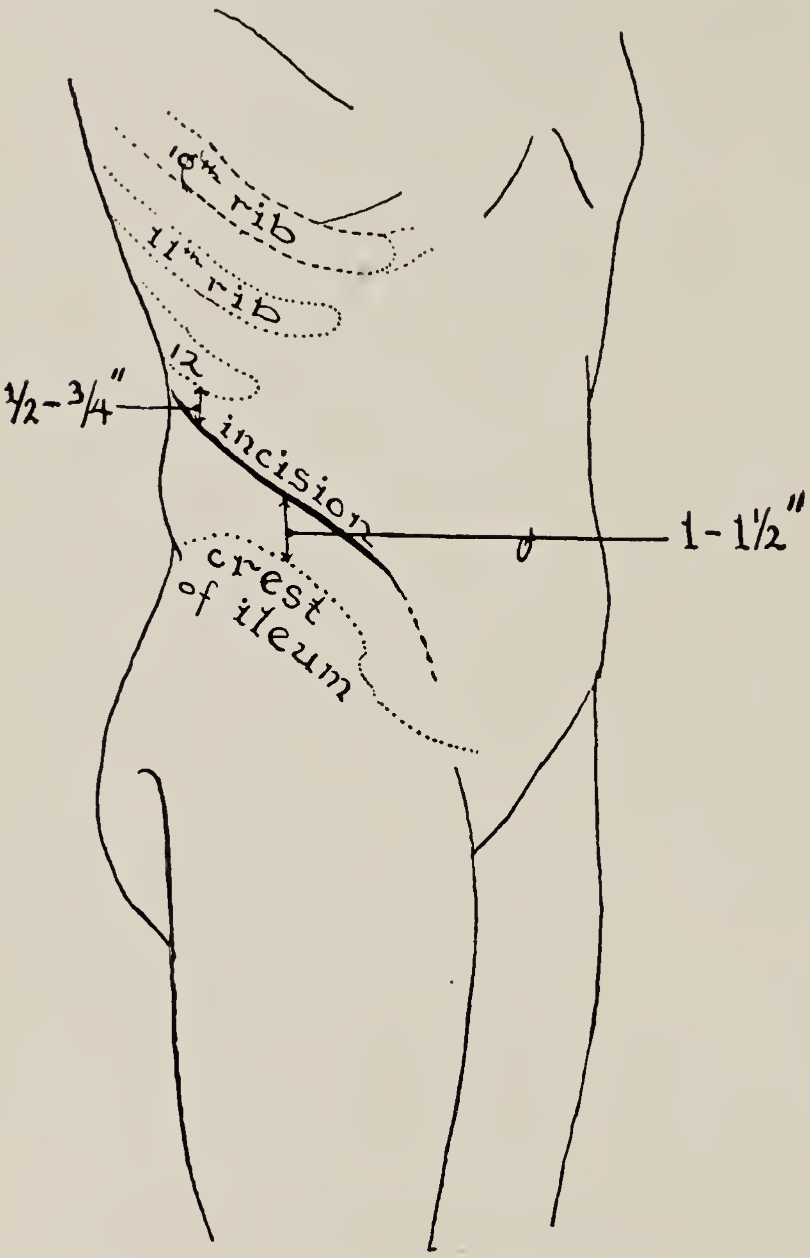

Fig. 30. Exposure of the entire ureter may be achieved through this incision. The dotted line indicates the approach to the lower ureter. It is not usually necessary to extend the incision for its entire length to do a nephro-ureterectomy.

Ureterotomy is usually performed for stone or stricture. Frequently a stone can be manipulated into the most accessible portion of the ureter. If this is not practical, the ureter is opened at the site necessary. Grasping the ureter at its distended or diseased portion, tape having been passed underneath, incision is made between Allis clamps in the long axis of the ureter. After separating all the coats with a small hemostat, a stone can be grasped with forceps or expressed digitally. Through the opening one explores, with a 7–10 F. ureteral bougie or flexible common duct dilator, the ureter up to the kidney and down to the bladder. Strictures when present are stretched to the desired size. Repair of the ureter is necessary when large stones have been removed. For this #000 plain catgut on an intestinal needle is used, interrupted sutures approximating the serosa and muscularis being used. Primary union of small incisions is usually

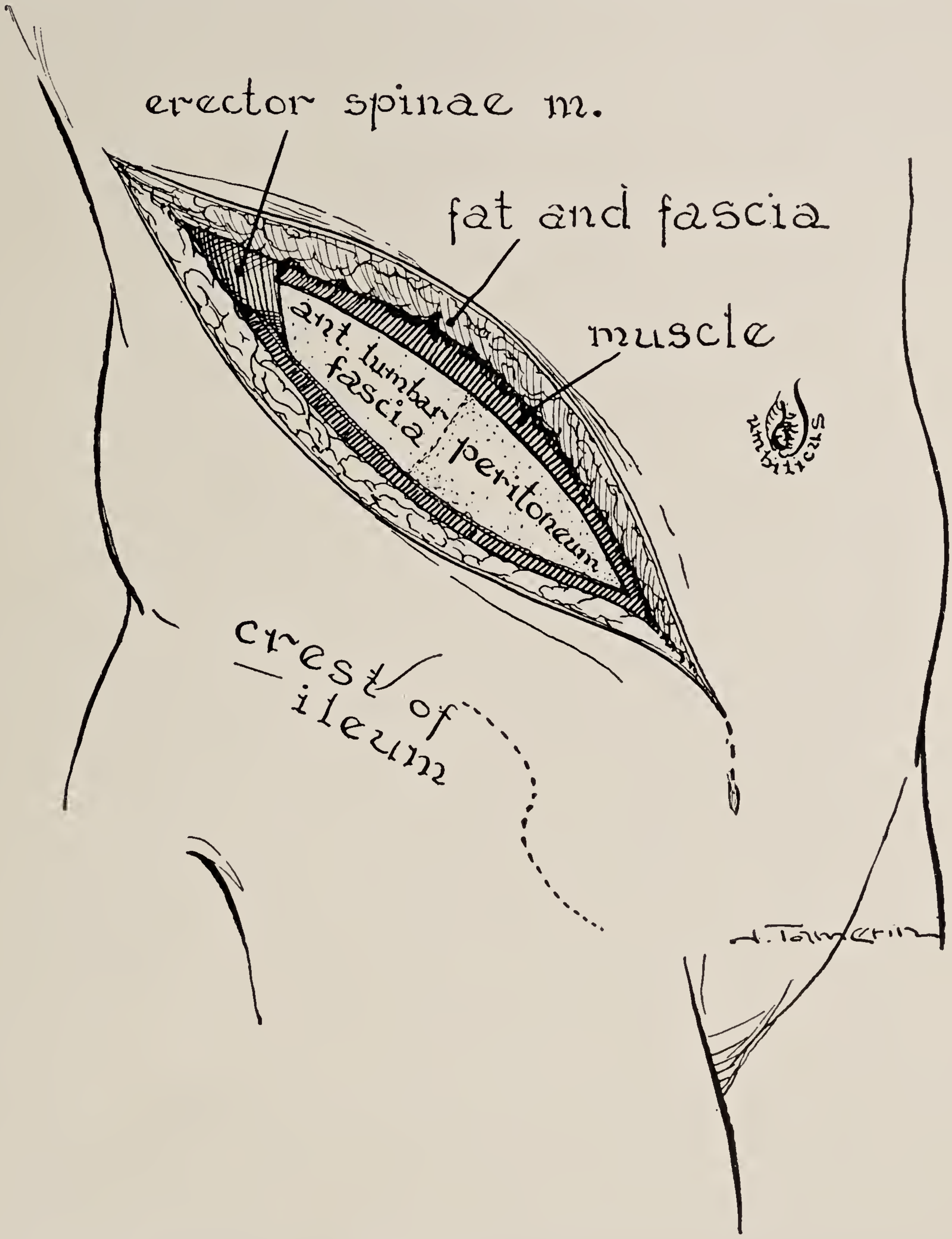

FIG. 31. Showing the superficial layers encountered in exposure of upper ureter.

obtained without such repair. Closure of the wound is done in layers with Penrose tubing or cigaret drains in the upper angle.

For stricture the Heinecke method as illustrated (Fig. 32 *C*), can be used. The exposure and closure are as previously described.

Ureterorrhaphy in the upper ureter is usually into the pelvis of the kidney for anomalies causing ureteral constriction as bands, accessory renal vessels, and S-shaped kinks due to anomalies or ureteropelvic inflammatory changes. Von Lichtenberg's operation of resection of a portion of the redundant pelvis and implantation of the ureter is described elsewhere (operations on the kidney).

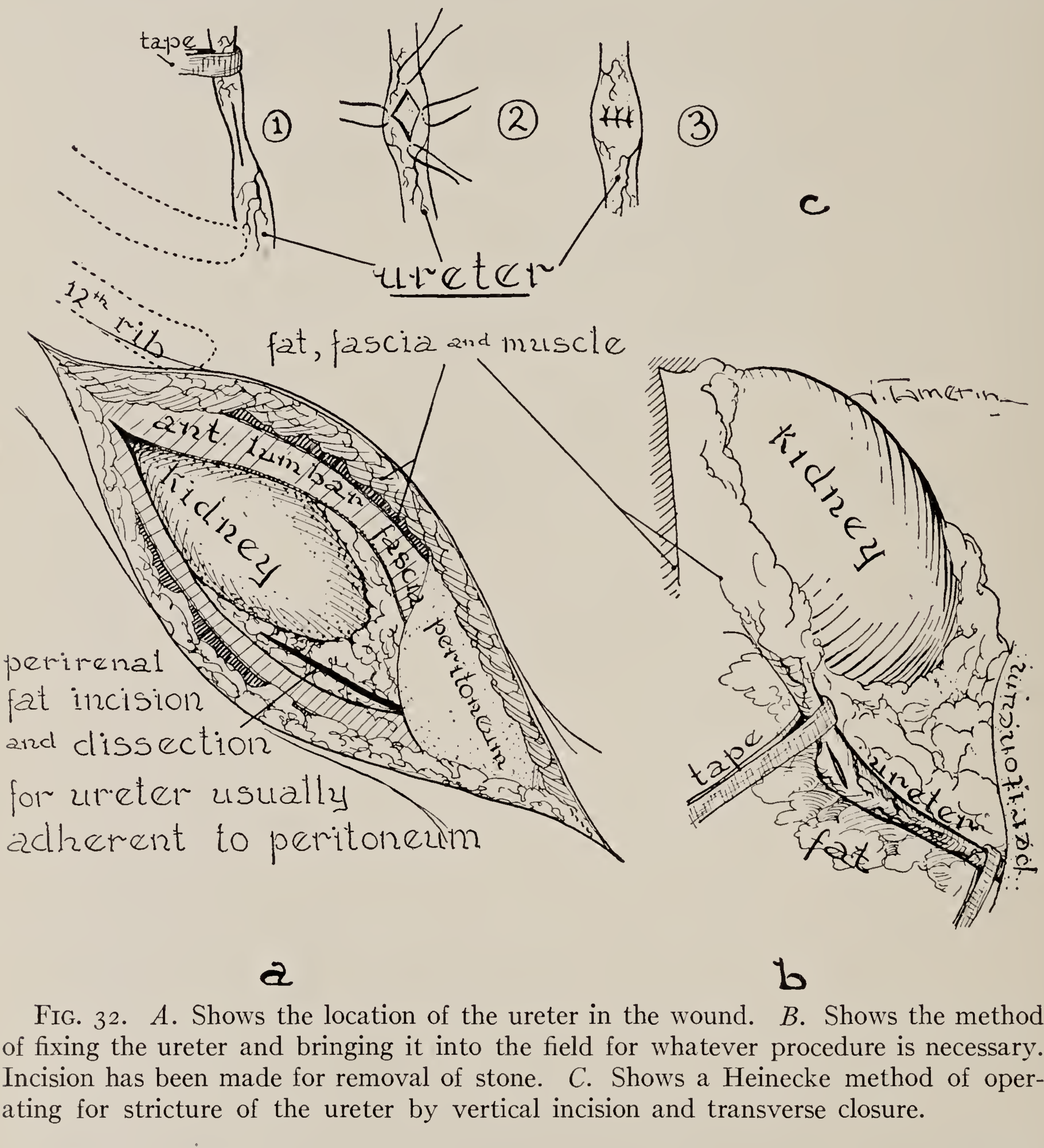

Fig. 32. *A*. Shows the location of the ureter in the wound. *B*. Shows the method of fixing the ureter and bringing it into the field for whatever procedure is necessary. Incision has been made for removal of stone. *C*. Shows a Heinecke method of operating for stricture of the ureter by vertical incision and transverse closure.

The mid-ureter is exposed through a downward continuation of the above incision or through a dorsal incision. Employed only for ureterolithotomy, this latter incision is made just lateral to the erector spinæ muscles. The lower end extends slightly laterally over the quadratus lumborum muscles. The procedure is similar, the structures encountered practically identical, and the operations performed upon the ureter through it are carried out as in the upper ureter.

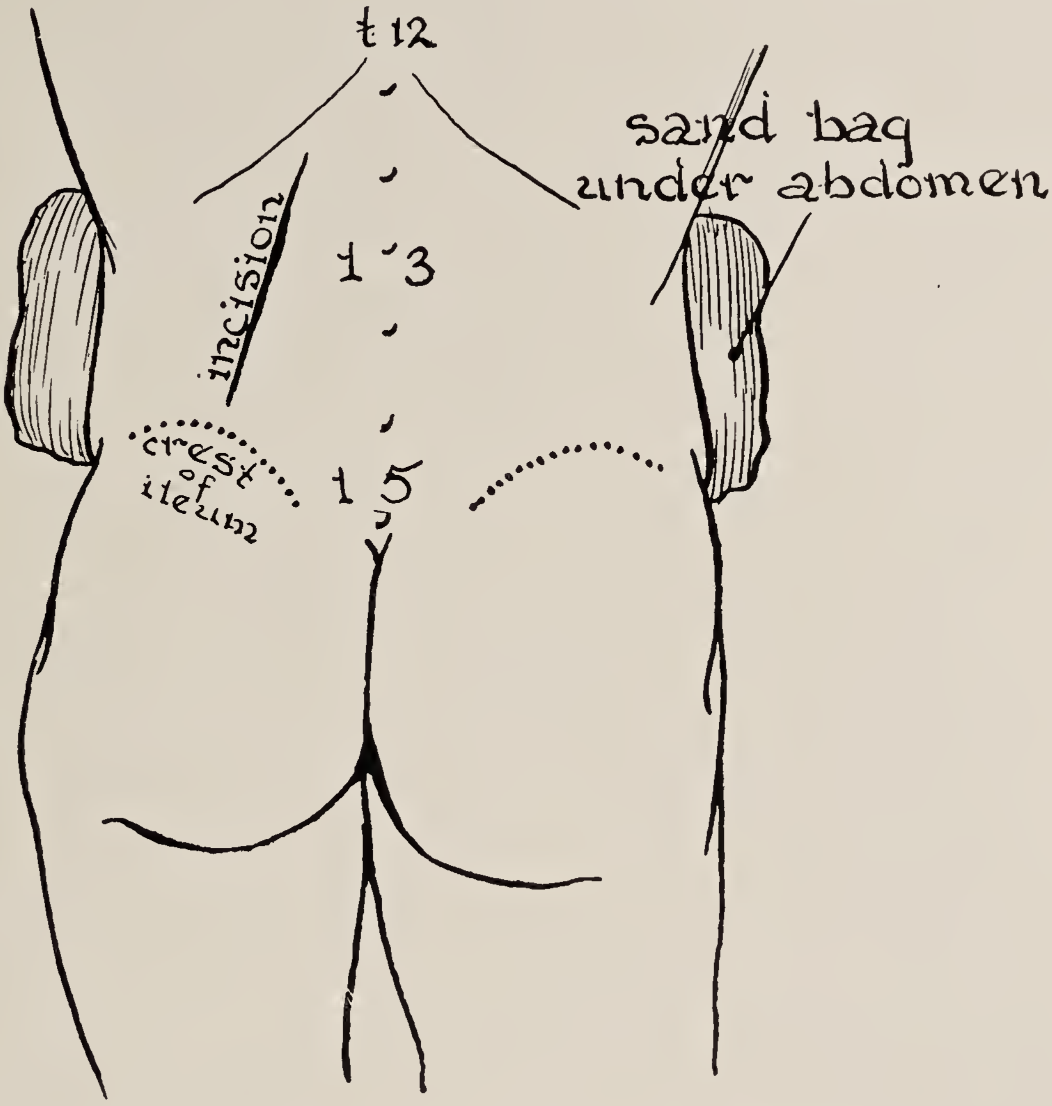

Fig. 33. Showing the approach to the mid-ureter.

The lower ureter may be exposed through a gridiron incision starting one inch away from the anterior superior spine, continuing downward and inward to a point one inch above and mesial to the pubic spine. Skin, fat, external oblique fascia, and muscle are divided. The internal oblique and transversus abdomenis muscles and fascia are divided in the direction of their fibers. It may be necessary to cut the rectus muscle and sheath for a fraction of its width. This exposes the peritoneum, which is rolled mesially. The sacro-iliac notch is next palpated. By turning the palpating finger anteriorly, the ureter is felt attached to the peritoneum. It should be separated by blunt dissection and as little as possible disturbed because of the neuro-vascular injury entailed. Tape is now placed around the ureter to bring into view the portion upon which operation is to be done. Ureterotomy necessitates dissection practically to the vesical insertion for stone in the terminal three centimeters. If the calculus can be milked up to a more accessible portion of the ureter, the operation is simplified greatly. If the calculus is adherent or, as rarely occurs, is in a pocket or diverticulum, the incision must be made at this site. Of some aid while working in such a field are deep retractors, with some sort of attached lighting mechanism. An increase in length of the instruments used, Allis clamps, plain forceps, small-stone forceps, bistoury scissors, probe, et cetera, to about eight inches is most helpful. After removal of the calculus the ureter is probed, and, if the incision does not gape, the ureter is dropped back into the wound without repair. Drains are inserted and closure made in layers similar to the gridiron incision.

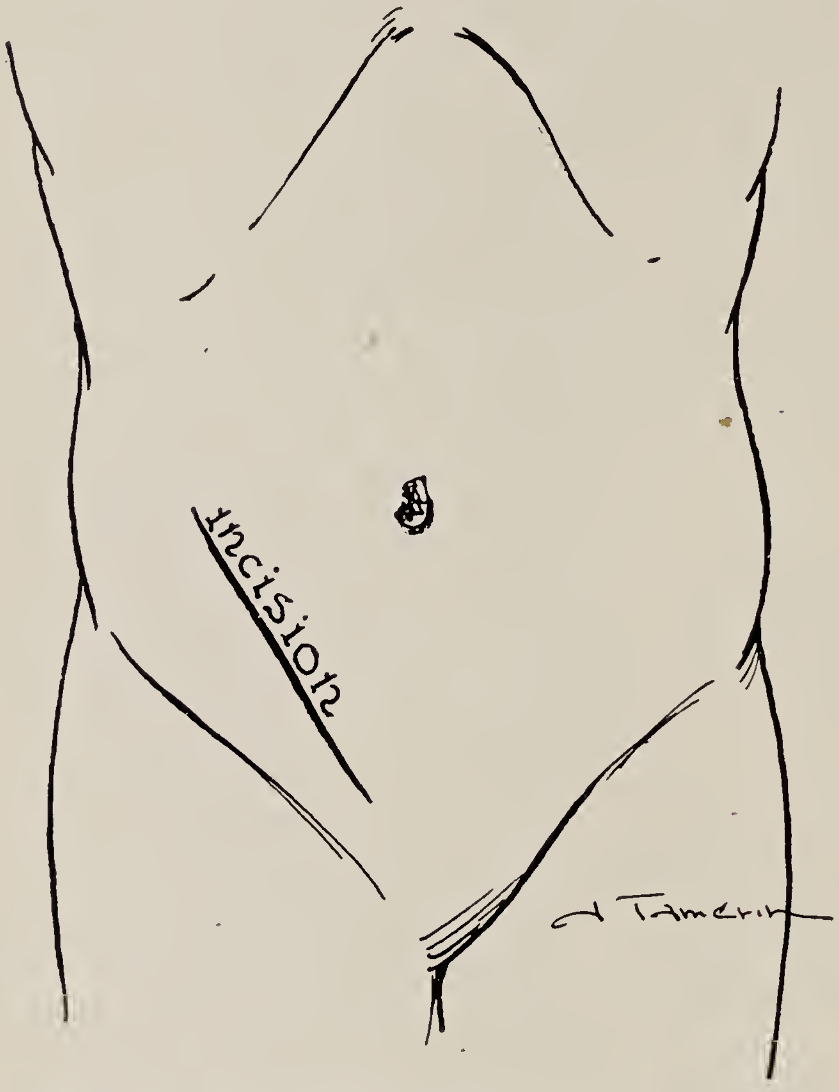

Fig. 34. Showing the approach to the lower ureter.

The foregoing descriptions include exposure of the different levels of the ureter as well as ureterotomy or ureterolithotomy in these sites.

Ureterostomy. For the lower ureter, a gridiron incision is used, and the ureter exposed and crushed by a hemostat. It is then ligated with #1 chromic catgut. The proximal end is mobilized for a distance that will permit bringing the exposed end up to the skin, and sutured in the lower angle of the wound. Closure is carried out with drainage as in ureterotomy. The area of skin, as well as the wound immediately adjacent to the ureter, should be covered with sterile vaseline gauze and dressings changed frequently.

Uretero-cystostomy includes, in addition to section and mobilization, the preparation of the bladder for anastomosis. Exposure is accomplished through supra-pubic incision usually made originally for resection of vesical tumor or diverticulum. Choice of a site in the bladder for the union is regulated by the amount of available ureter and the mobility of the bladder wall, it being imperative that the two unite without tension. A small hemostat is pushed through the bladder obliquely from its outside, and the opening enlarged sufficiently to accommodate the ureter snugly without constriction. Emphasis is placed upon the obliquity when possible. Tunneling under the mucosa less than 1 cm. before entering the bladder cavity usually suffices to establish a satisfactory valve. Markedly

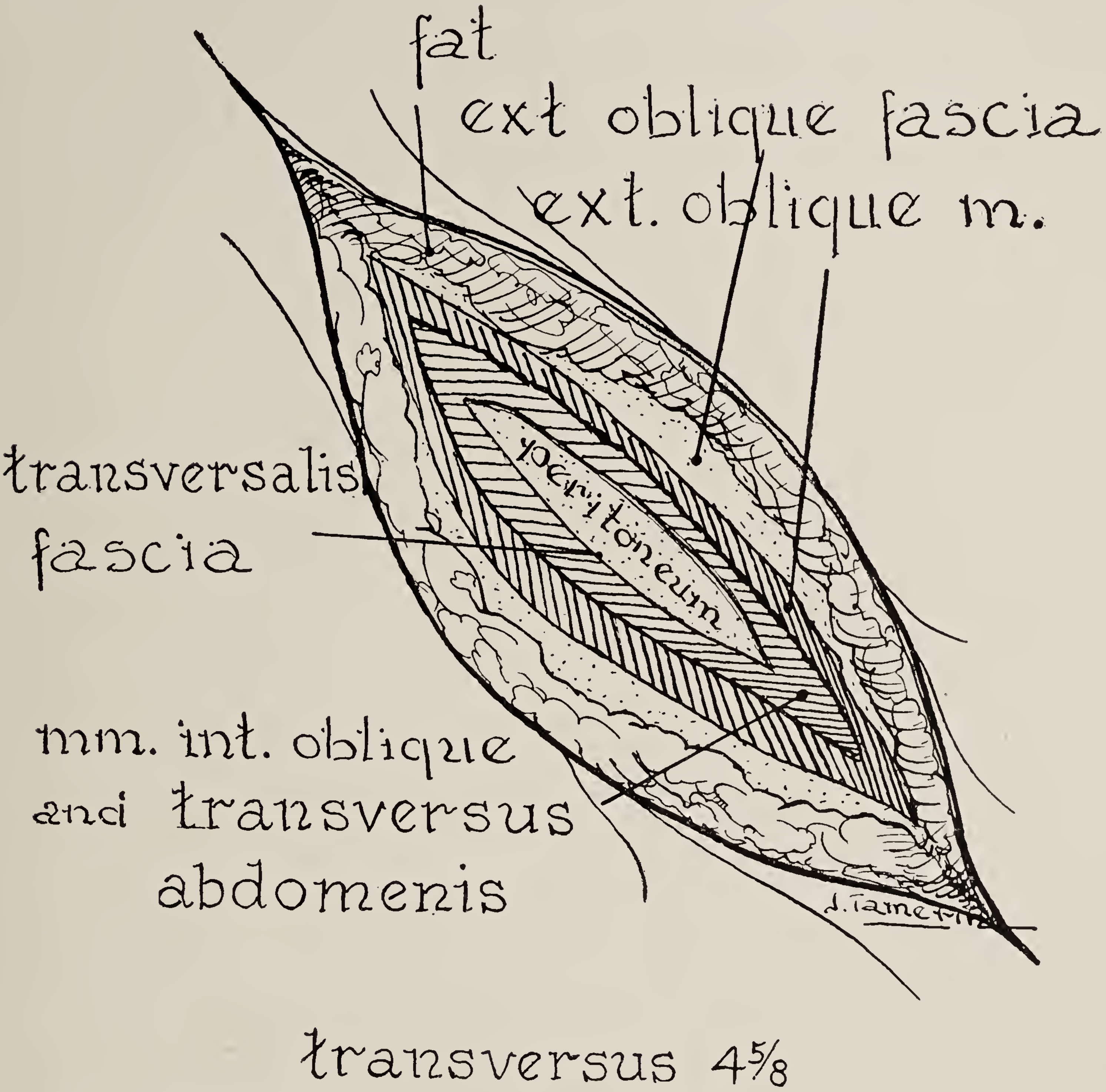

FIG. 35. Showing the structures encountered in the gridiron incision for exposing lower ureter.

shortened ureter or contracted bladder necessitate the most direct anastomosis possible and preclude the possibility of valve formation.

The ureter end having been brought through the bladder wall, it is anchored at the junction with a suture on either side (#0 chromic). The terminal ureter is split into quadrants, each of which is sutured to the mucosa. When tension threatens the integrity of the anastomosis, a #10–12 F. ureteral catheter may be introduced to the kidney, and left in position five days, after which it may be recovered cystoscopically. The wound is closed with drainage pre- and post-vesical and the usual cystotomy tube.

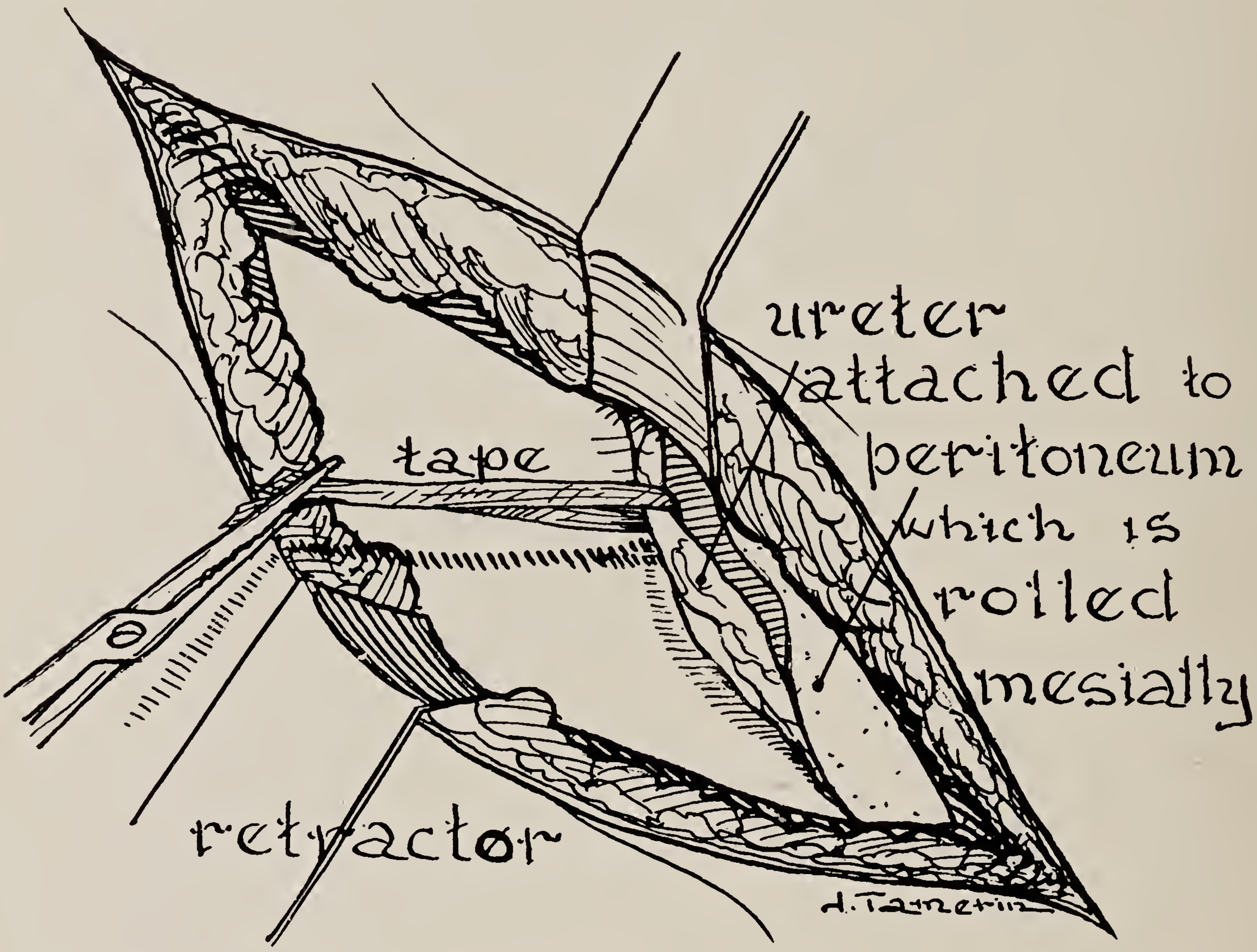

Fig. 36. Exposure of the ureter by rolling and retracting the peritoneum mesially.

Uretero-enterostomy. The operation universally used is that of Dr. R. C. Coffey, whose description and illustrations are largely used.

The bowel having been properly emptied by catharsis and a light diet several days previous to the operation, the patient is prepared, and under general or spinal anesthesia a mid-line incision is made to open the peritoneal cavity. The sigmoid is isolated, packed off and clamped with stomach clamp about 12 to 14 inches above the anus. The patient's position

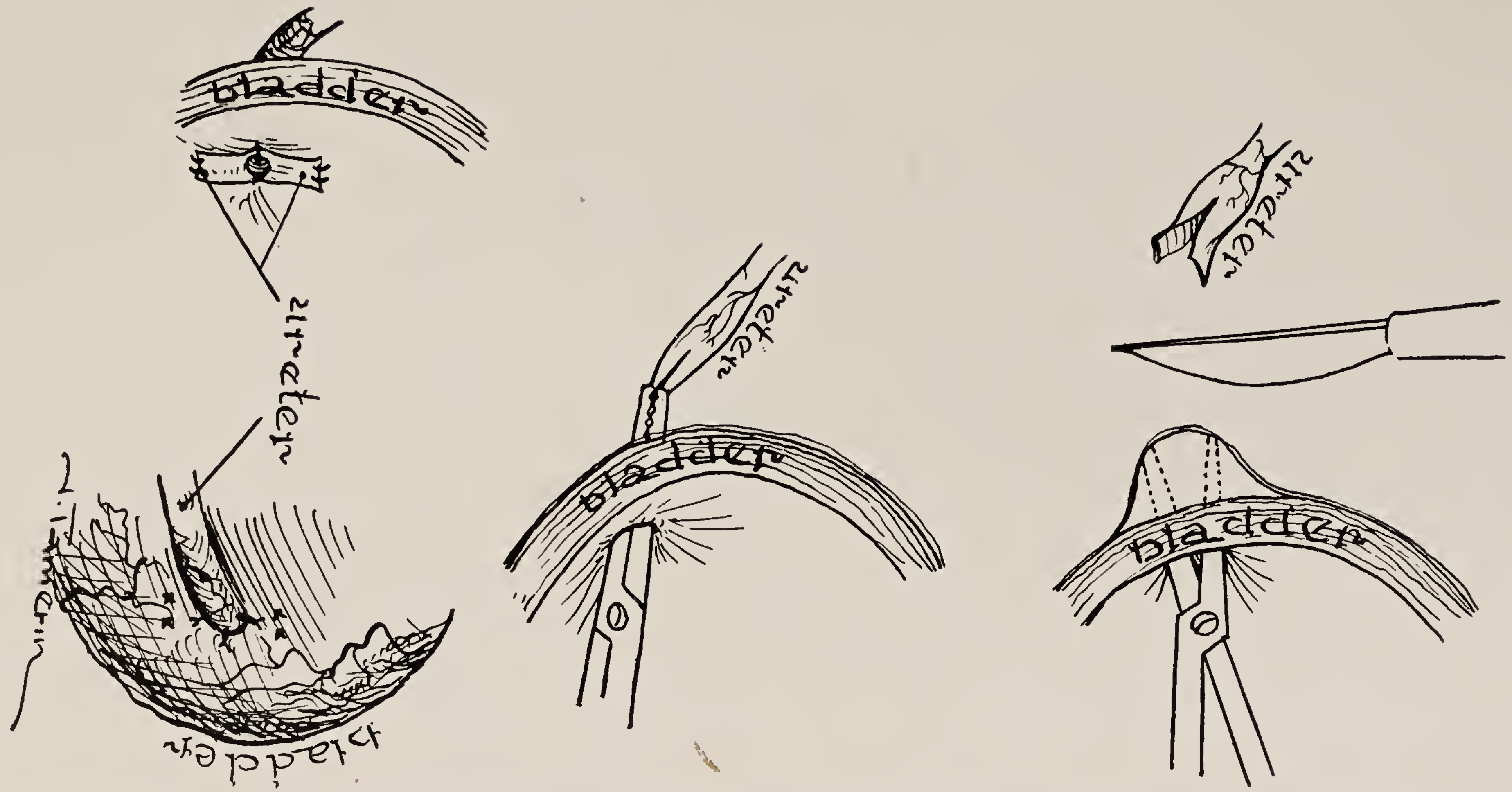

FIG. 37 shows the method of transfixion of the bladder and the method by which the ureter is anchored to the bladder.

is then changed to permit a sigmoidoscope 30 cm. long into the rectum. The isolated segment of sigmoid is irrigated with 1 per cent. mercurochrome applied through a needle by the operator, the sigmoidoscope being gradually withdrawn to permit thorough irrigation. Following this irrigation the instrument is reinserted, the lower bowel packed with two-inch gauze, during which the sigmoidoscope is again withdrawn. The posterior parietal peritoneum is next incised over one ureter which is freed, ligated at its terminus, and the vesical stump ligated after carbolization. The second ureter is now freed and prepared in a like manner, after which #12 F. whistle-tip ureteral catheters, prepared by fastening a rubber cuff about 20–25 cm. from the tip, are inserted into the ureters. Two strong linen ligatures are then tied around the ureter and cuff. The third is placed around the ureter above the cuff.

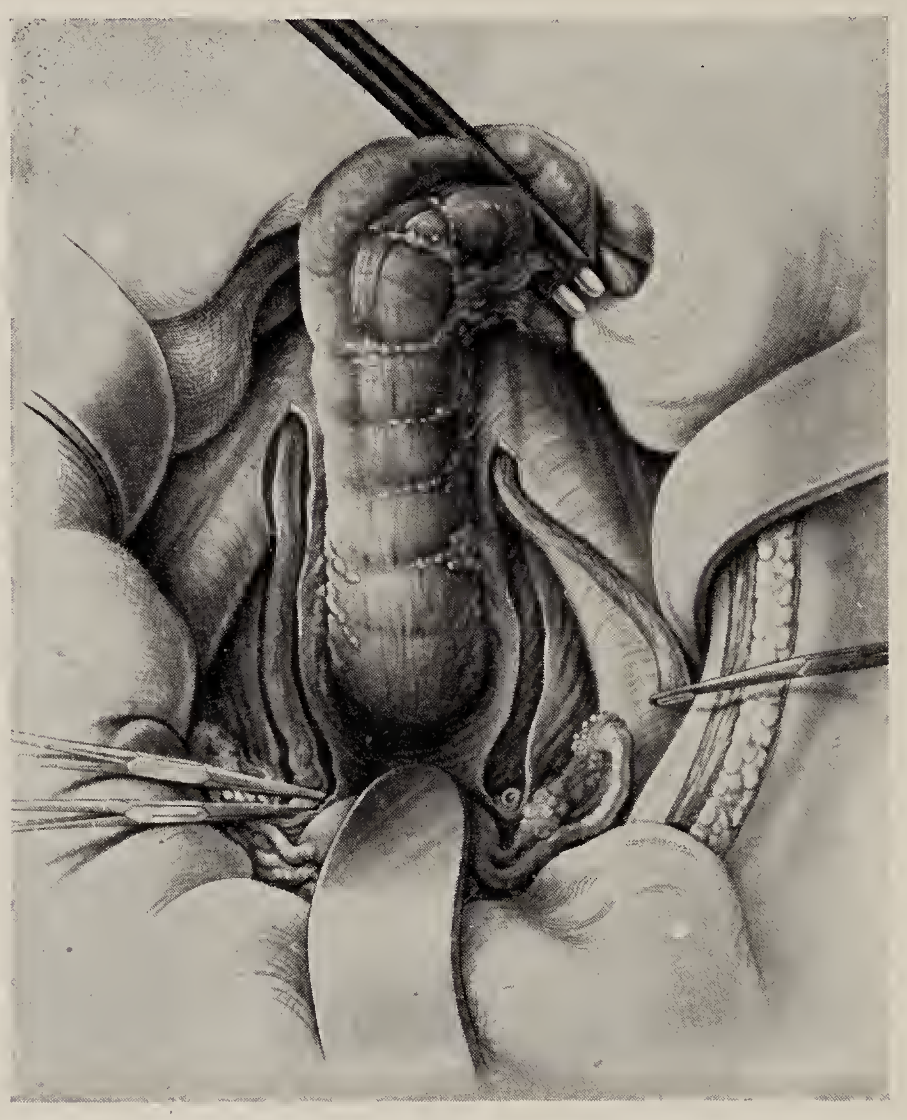

FIG. 38. This illustrates the sigmoid clamp in position. The parietal peritoneum has been incised to demonstrate both ureters and their relations. The clamped terminal ureter is pictured. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

Separate incisions are used for the transplantation, the left being placed at a lower level than the right. These incisions are made diagonally, extending from the mesentery edge downward and toward the mid-line of the intestine. The lowest site accessible to the left ureter having been selected, two traction loops of #00 catgut are placed at each end of the proposed incision about one-half inch apart. The incision is then made carefully through the peritoneal and partially through the muscular coat, the remaining muscular fibers being dissected minutely down to the mucosa, after which the mucosa is freed on either side of the incision from the muscularis. The site selected for the transplantation of the right ureter is treated in a like manner. By encircling the sigmoid with the finger, the gauze is pushed against the incision through the upper part of which a stab wound is made permitting a small forceps to enter and pull a bit

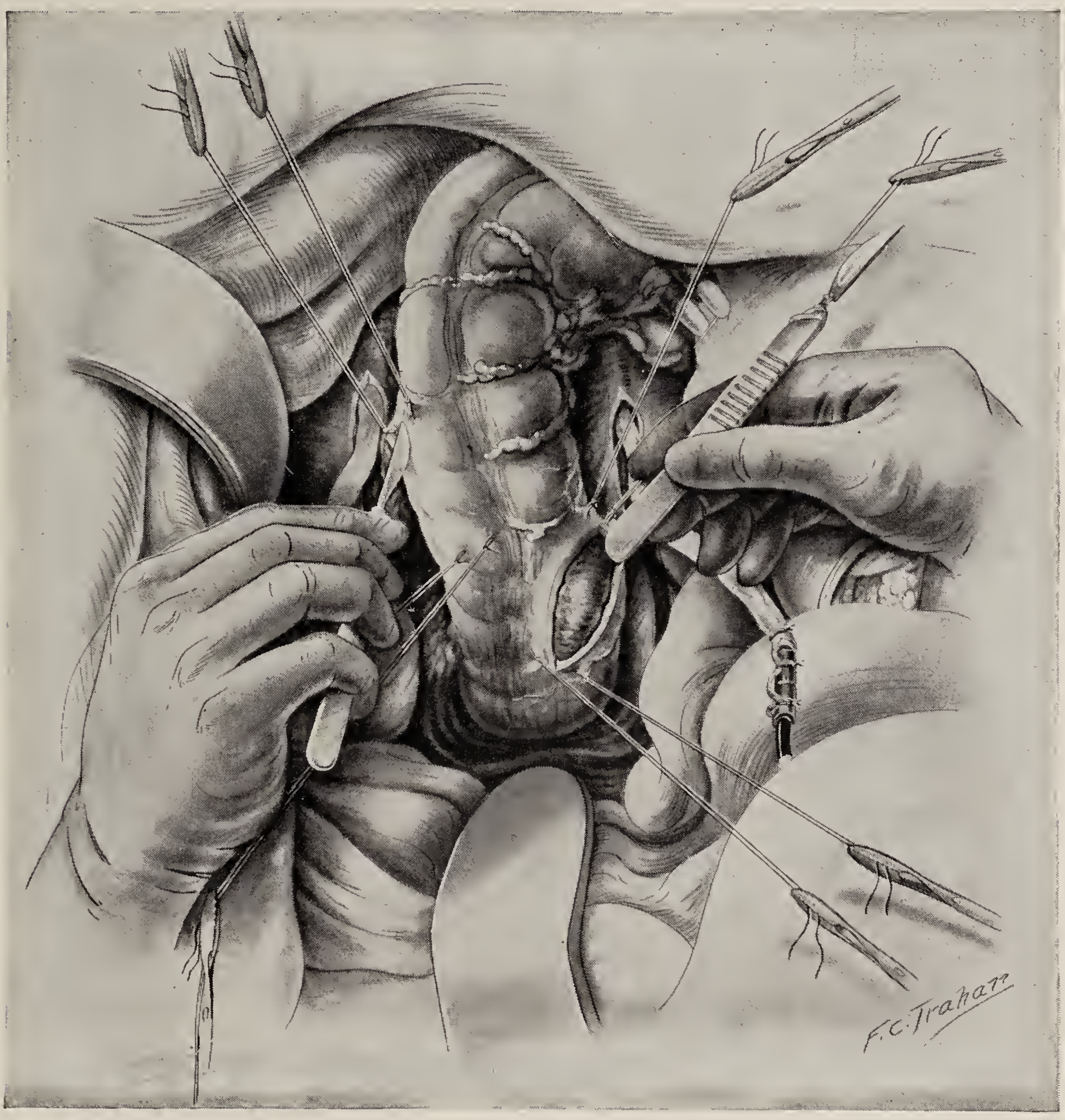

FIG. 39 shows the traction loops; the incision for the left ureter has been made and the mucosa exposed. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

of gauze through the puncture. The tips of the two catheters are next sewed to the gauze thus brought into the wound, one catheter having been cut obliquely to permit identification later. The gauze is now gradually withdrawn until the lower catheter appears, care having been taken to accommodate the size of the opening into the bowel to the cuff around the catheter. The second catheter is then brought down until the juncture is accurately secured, and the balance of the gauze is removed. The

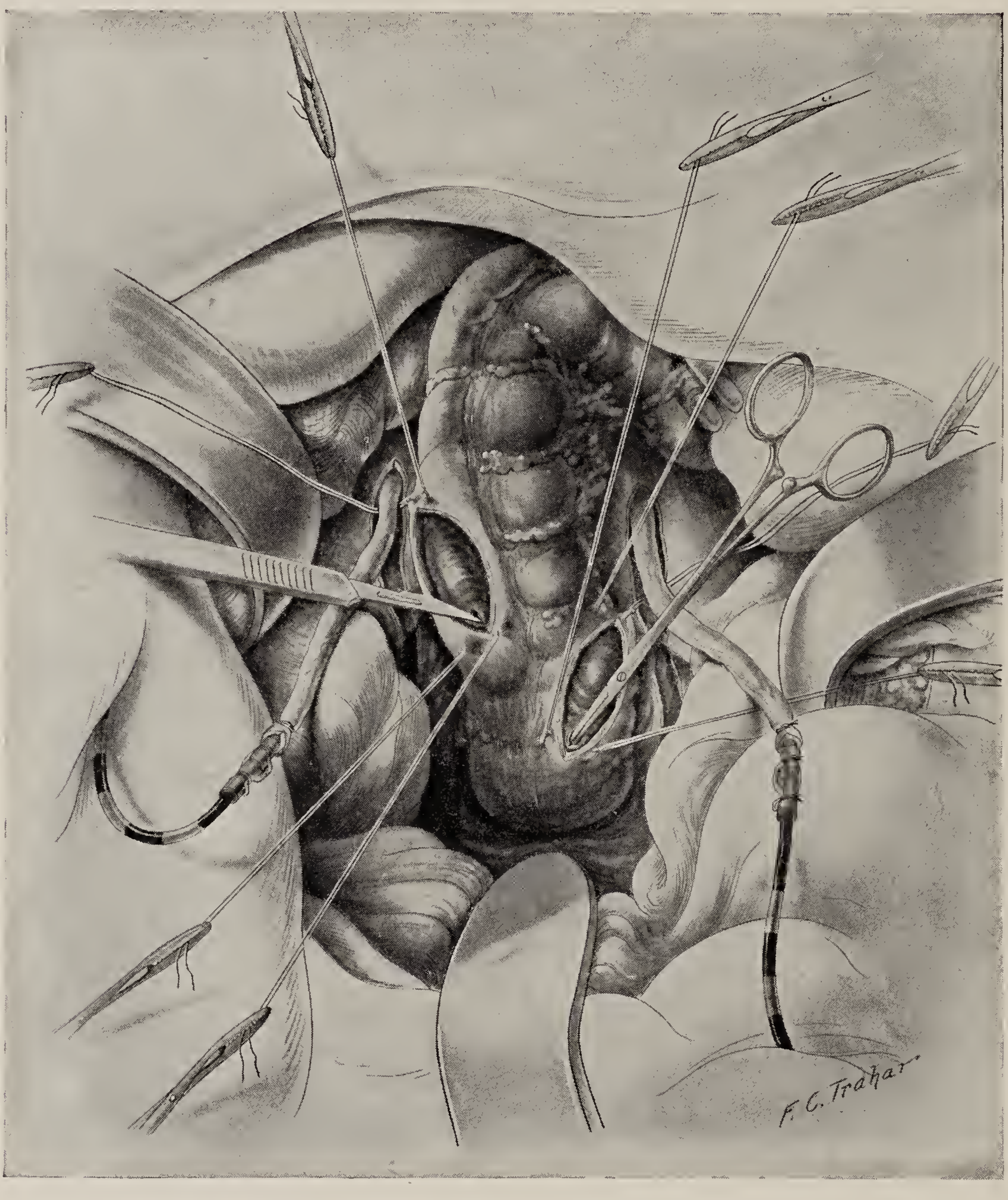

FIG. 40. The two ureters with cuffed catheter fixed in position and incision into the mucosa. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

ureter is next fixed by #000 chromic catgut which includes peritoneum, musculature, and mucosa of one side of the incision as well as a good bit of ureteral wall. The other side of the ureter is likewise fixed. The intestinal wound is then closed over the ureter with #0 catgut. The completed operation should show ureters completely covered by peritoneum. Drains are placed in the retroperitoneal space and in the cul-de-sac. The folded sheets of gutta percha tissue cover the gauze so that no intestine can touch it. One week after operation, gauze wicks are withdrawn. Seven days later the gutta percha is removed.

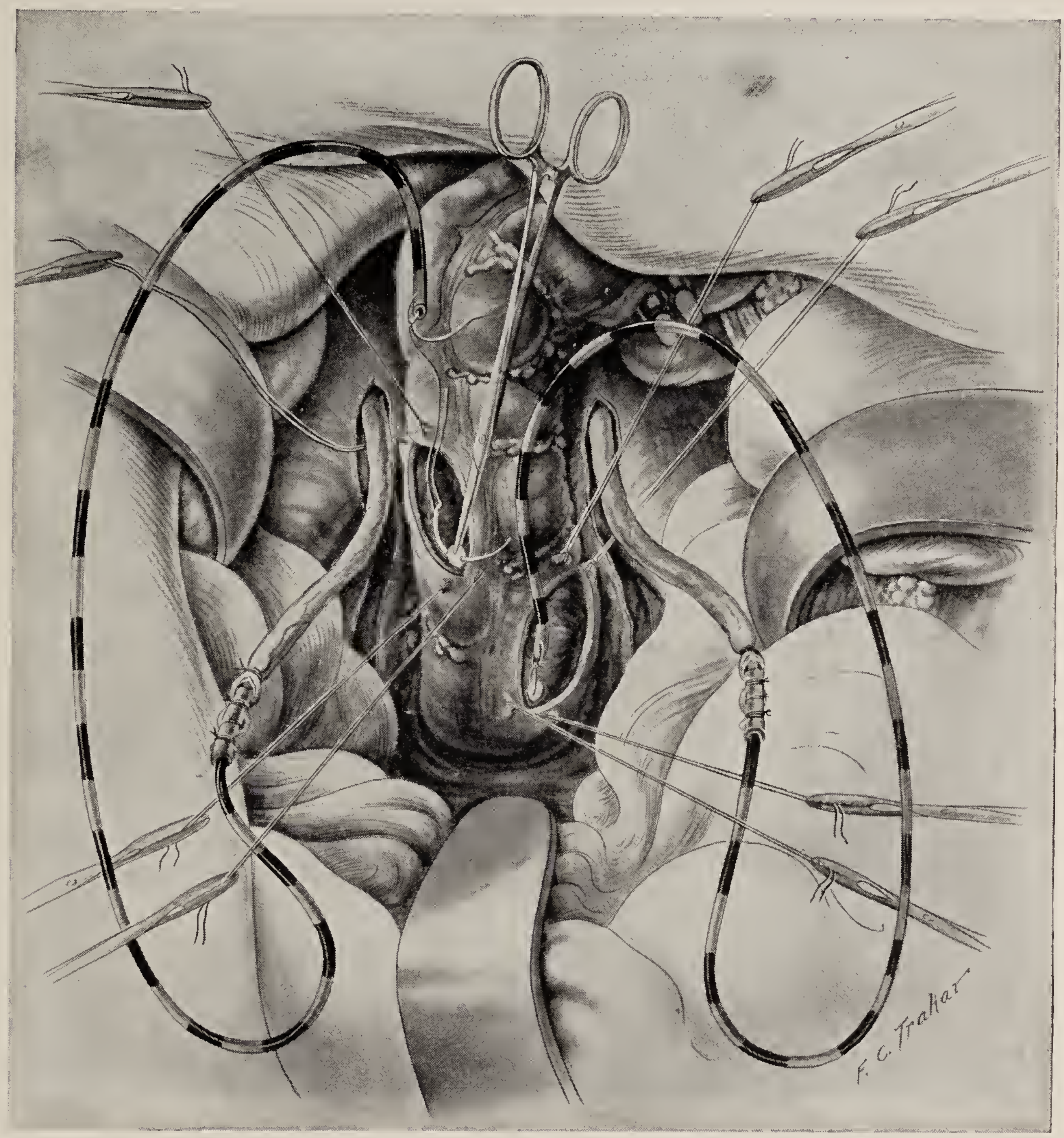

Fig. 41. The tips of the catheter are here seen affixed to the intrasigmoidal pack ready for placing. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

Ureterectomy. For this operation, when combined with nephrec-

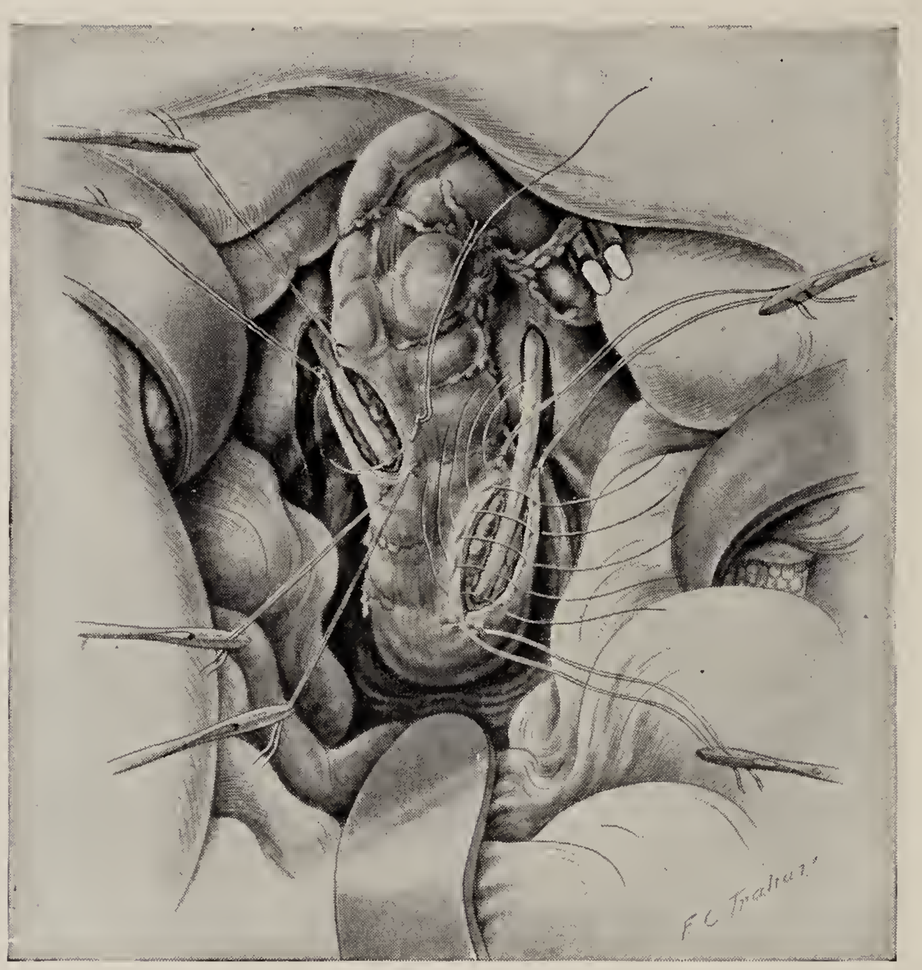

Fig. 42. Fixation of the ureteral stumps. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

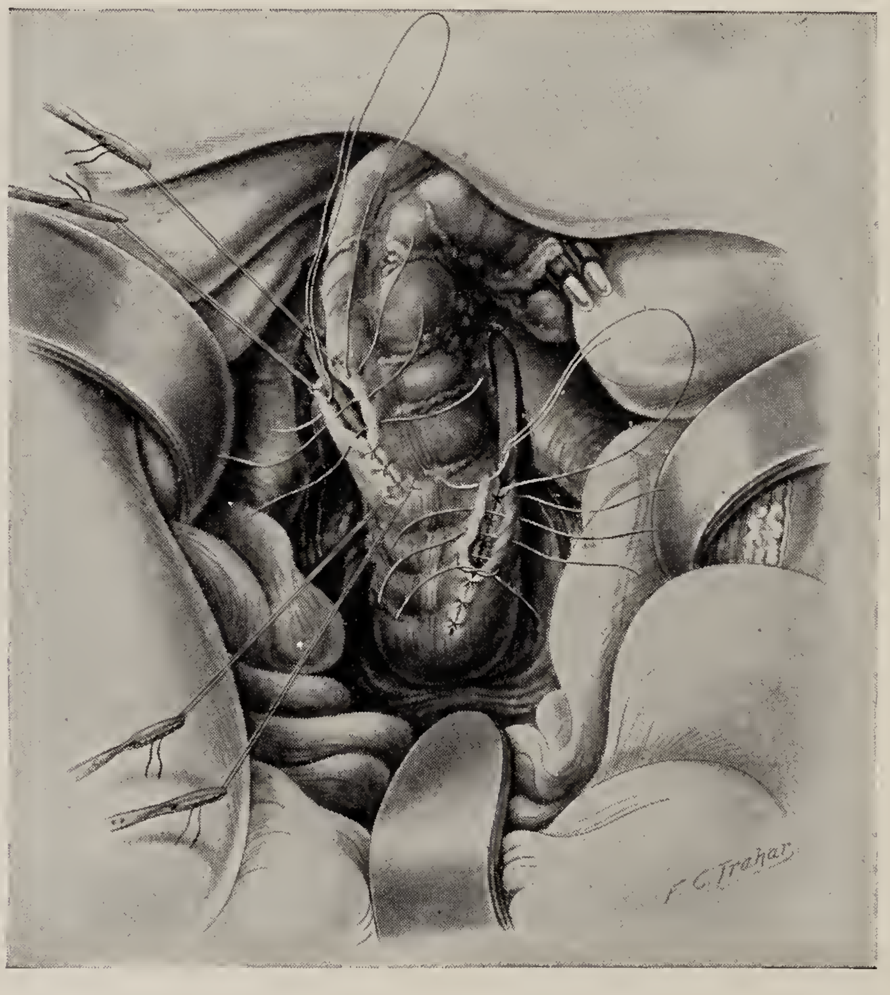

Fig. 43. The method of burial of ureter in the intestinal wall. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

tomy, the loin incision may be extended farther anteriorly and downward, freeing the ureter as close to the bladder as possible, at which point clamps are applied. The ureter is crushed, ligated with #1 chromic catgut. The ends are carbolized. Closure with drainage is safest.

Secondary ureterectomy is best attempted through a gridiron incision which may be lengthened forward to the loin if necessary. If a catheter can be inserted into the ureter before operation, it assists in locating the ureter. The remainder of the procedure is as previously described.

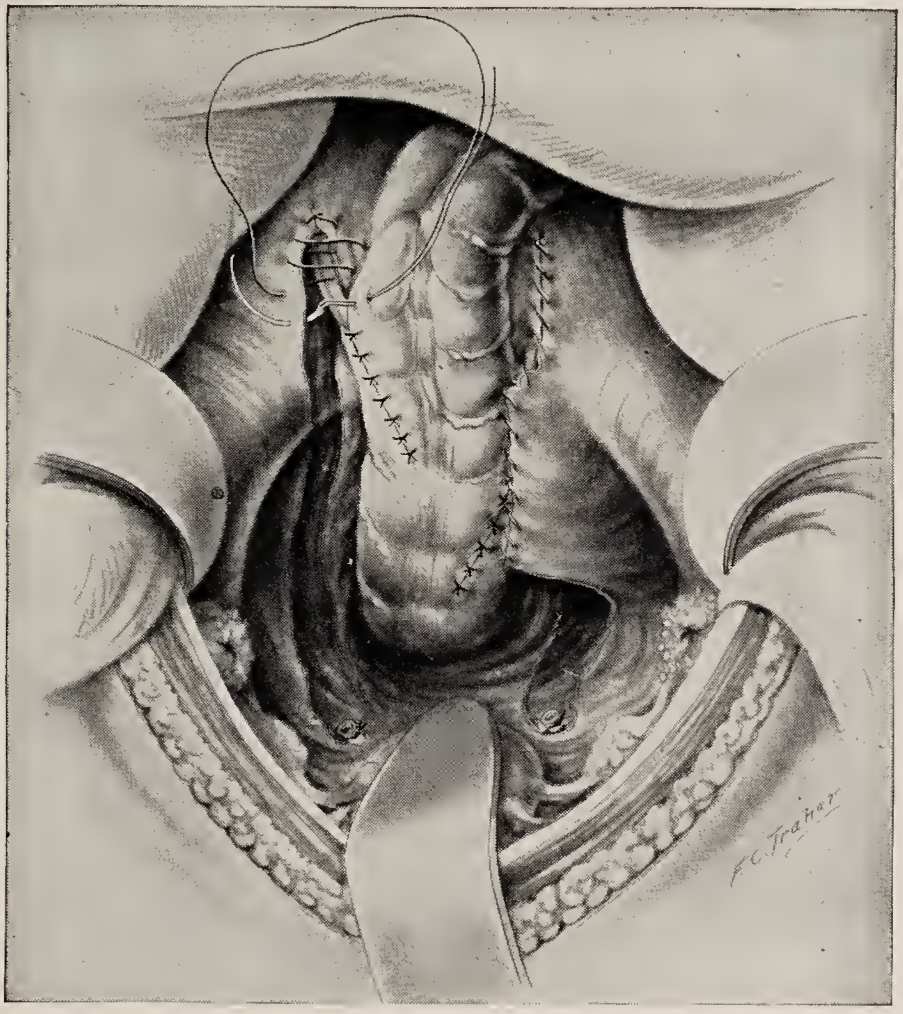

FIG. 44. Showing the method of obliterating space between ureter and sigmoid and provision for retroperitoneal drainage. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

Uretero-ureterostomy. Anastomosis of two portions of the ureter may be necessitated by injury or accident during operation. This is simplified by passing a ureteral catheter by cystoscope to the damaged area. Both fragments are approximated and the catheter is passed into the proximal end. The segments are then united by interrupted sutures and the catheter is left *in situ* for 3 to 5 days to facilitate drainage and healing.

CARE OF URETER AFTER OPERATIONS

All operations upon the ureter are followed by scar and potential stricture. For this reason it is necessary, if late morbidity is to be avoided, to dilate such ureters at regular intervals. In many, annual or bi-annual dilatation will suffice. Where infection has been prominent in the etiology or convalescence of the condition, more frequent observation is desirable.

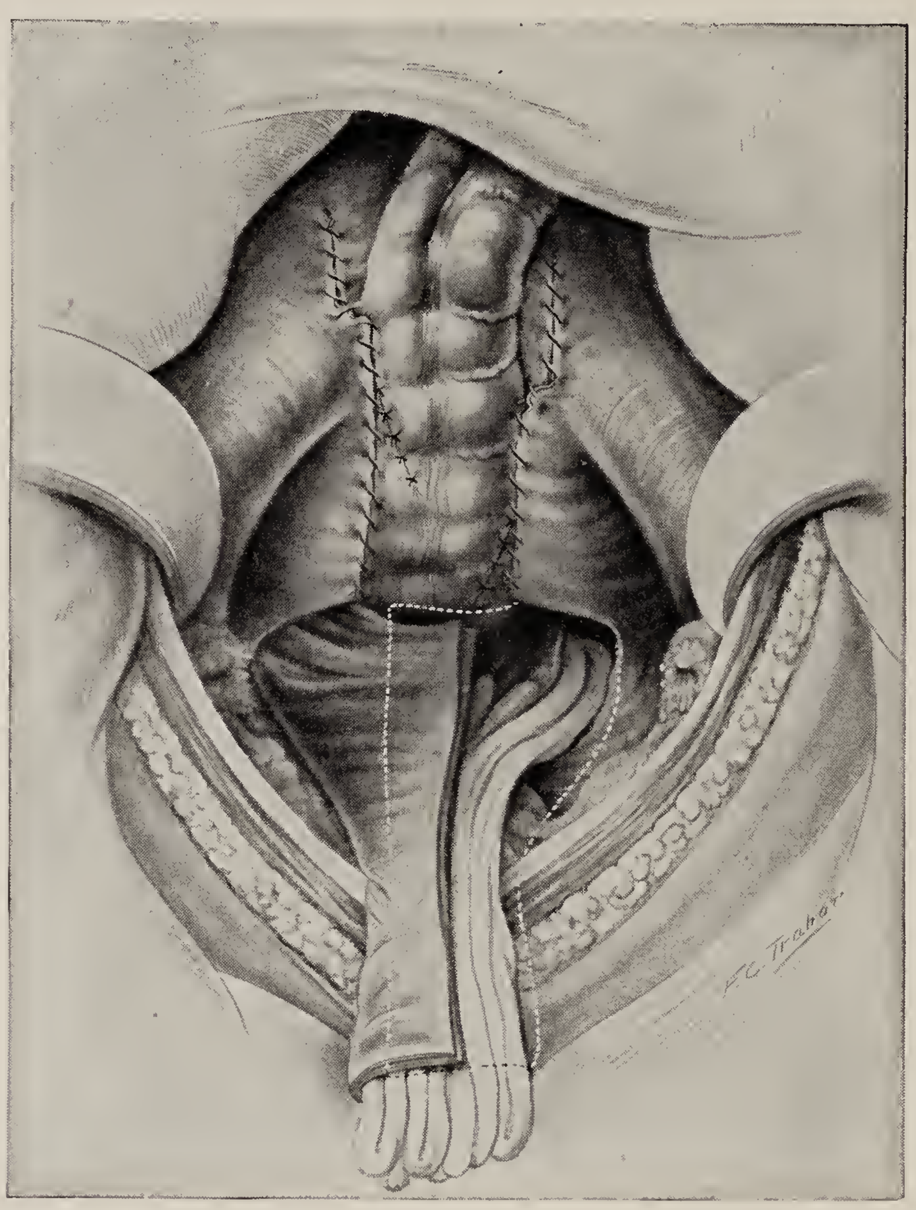

FIG. 45. Showing position of drains. (Courtesy of the Surgery, Gynecology and Obstetrics Journal.)

With intravenous urography, it is now possible to observe the function of uretero-enterostomized patients periodically for prognostic and occasionally therapeutic purposes.

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EMBRYOLOGY AND SURGICAL ANATOMY OF THE KIDNEY

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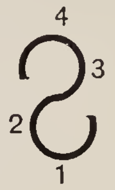
THE DEVELOPMENT OF THE METANEPHROS

The adult mammalian kidney is the third kidney to develop in the individual. It is preceded by the pronephros, a very transitory structure, and by the mesonephros, which persists in part even in the adult. In the male it gives rise to the ductuli efferentes and ductus epididymis; also to certain rudimentary structures. All three kidneys arise from the intermediate cell mass of mesoderm lying lateral to the dorsal aorta. The pronephros, or head kidney, is the most cephalic in development, the mesonephros overlapping and following the pronephros, with the metanephros the most caudal of the three. Both the pronephric and mesonephric tubules arise segmentally in the intermediate cell mass and acquire openings into a common passage, the Wolffian duct, which in turn opens into the urogenital sinus. It is from this duct and from undifferentiated cells of the caudal portion of the intermediate cell mass or nephrogenic cord that the definitive kidney or metanephros arises. From the Wolffian duct the entire duct system arises. This includes ureter, pelvis, papillary ducts, collecting and arched tubules. From the nephrogenic cord comes the entire glandular or secreting part of the kidney; that is, renal corpuscle, convoluted tubules and loops of Henle, and probably also the capsule of the entire organ. Thus, we see that the metanephros has a double origin.

In human embryos of about five mm. there occurs a dorsal outpocketing of the Wolffian duct near its caudal end where it bends sharply ventrad to enter the urogenital sinus. This outpocketing, capped by cells of the nephrogenic cord, is at first rounded at its free end but soon expands and becomes somewhat bilobed (10 mm. embryo), and the terms cephalic and caudal pole tubules are given to these expansions. A bit later (embryo 12.5 mm.) generally two central outpocketings develop, although one to four may form. These four primary tubules open into the future pelvis of the kidney represented by the expanded end of the outpocketing of the Wolffian duct, which in itself is the anlage of the ureter and grows to produce the ureteric tree. The distal ends of the primary tubules grow into somewhat flattened expansions, each of which sprouts out from two to four tubules of the second order. These in turn sprout out tubules of the third order and so on until finally twelve generations of tubules are formed, the last representing the adult terminal collecting tubules. In this expansion of the ureteric tree, the cephalic pole tubule and caudal pole tubule are less crowded and branch more freely than the central tubules. As the pole tubules develop they expand in a fanlike manner about the pelvis. In the formation of the adult sinus the widening of the tubules of the first and second order produce the major calyces and minor calyces which vary in number from 9 to 20. Into the calyces minor open directly tubules of the third, fourth, and fifth orders, this being accomplished by the taking up of the proximal portions of the tubules of the third and fourth orders into the walls of the expanding minor calyces. These tubules are the papillary ducts which secrete the urine into the pelvis and there are from twenty to thirty for each calyx minor. Great variation occurs in the form of the pelvis. At times the major and minor calyces themselves are taken directly into the wall of the pelvis proper, leaving only shallow depressions into which the papillæ open.

We have thus far described merely the collecting apparatus, but it must not be forgotten that a parallel development of the cortical cell mass, derived from the nephrogenic cord, has been going on. As the ureteric tree branches, the cap of cells overlying the dilated end is at first actually divided by these outgrowths. These separate masses again unite by the formation of a thin layer of cells between the individual caps of the tubules. With each succeeding generation of branches we find a corresponding division of the cell mass capping the blind end of the tubule. These caps are differentiated into metanephric spheres in which appear cavities, so that the term metanephric vesicle becomes more appropriate. From these metanephric vesicles develop the secretory part of the uriniferous tubules. The essentials only of this development will be given here. Briefly, an S-shaped tubule is developed from the sphere, the portion designated by the numerals 1 and 2 being nearer the pelvis of the kidney and 3 and 4 near the surface. From portion 1 is developed Bowman's capsule into which an arteriole grows to form the glomerulus; portion 2 develops into the proximal convoluted tubules; 3 into Henle's loop, and 4 into the distal convoluted tubule which is united with the collecting system through an arch of the collecting tubules. The first uriniferous tubules are developed in connection with collecting tubules of the fifth and sixth orders. In the adult, however, the cortical tubules are connected exclusively with collecting tubules of the twelfth order which have grown out into the cortex as medullary rays. It is, therefore, certain that the youngest tubules have changed their connections with the duct system, but the manner in which this is done remains obscure at present.



The cortex not only develops about the medulla but actually penetrates into the medullary tissue forming the renal septa. At first the septa are merely extensions of the cortex and its connective tissue between the primary Malpighian pyramid, the apex of each being represented by a pole tubule or tubule of the first order. Later, however, with the branching of the primary ureteric trees, additional secondary and even tertiary renal septa invade the primary Malpighian pyramids, subdividing them and finally resulting in the formation of as many as nine secondary pyramids from one primary. The secondary and tertiary renal septa may reach the border of the pelvis by the absorption of collecting tubules of the third and fourth orders into the minor calyces. They also produce depressions in the surface of the developing kidney, giving it a distinct lobed appearance. The areas delimited by these grooves are secondary or even tertiary lobes. This lobed condition persists even after birth and sometimes into adult life.

The development of new uriniferous tubules continues for about ten days after birth, and after that no new tubules are formed, subsequent growth taking place in the enlargement of tubules already present. Especially noticeable is the lengthening of the convoluted tubules from childhood to adulthood. They also double their diameter. This increase serves to separate greatly the renal corpuscles and to form a distinct layer of tubules devoid of corpuscles just beneath the capsule.

Position and Growth. The original outpocketing of the Wolffian duct, to form the ureteric bud, was at the level of the fifth lumbar segment. By the growth of the ureter the pelvis is pushed cephalad to the second lumbar segment (embryo 9.5–13 mm.). From this position there is but little change throughout development. It is chiefly a matter of growth of the region in which the anlage lies and growth of the organ itself which, in the first half of fetal life, allows the kidney to extend through the first three lumbar segments and in later fetal development from the eleventh thoracic to the fifth lumbar. The right kidney develops less favorably than the left, due to the interference of the liver on the right side. There is a rotation of the kidney on its long axis in development. At first the ureteric tree is dorsal to the ureter. Later it comes to lie lateral to the ureter, and finally, with the formation and growth of the bodies of the lumbar vertebræ, it comes to occupy a position intermediate to the sagittal and frontal planes.

The origin of the renal arteries accounts for their wide variability. The mesonephros was supplied by a number of branches from the dorsal aorta. These branches form a network, and this network subsequently becomes connected with vessels which develop and grow into the metanephros. A direct connection is then formed from the aorta to the kidney generally by the enlargement of one of the mesonephric vessels on each side. If, however, several vessels enlarge, a duplication or branching of the renal artery occurs.

Anomalies. Various defects in development show themselves in the kidneys and ureters. A cystic kidney is probably caused by the failure in the union of collecting tubules and uriniferous tubules. By a functioning of the latter without outlet the cyst is formed.

At times the embryonic mesodermal tissue which forms the cortex is united across the mid-dorsal line, and the developing kidneys grow with a connecting strip between them giving rise to a horseshoe kidney or even to a single disc-like organ. Another anomalous condition is the retention of the fetal lobation of the kidney, much as persists in animals like the beef.

Not infrequently there is either a total or partial reduplication of the ureters. In the former case it is probably due to a branching of the original ureteric outpocketing, but in the second case, where two or more separate ureters open individually into the urinary bladder, it is possibly due to several outpocketings originally formed from the Wolffian duct.

SURGICAL ANATOMY OF THE KIDNEY

The anatomical position of the kidney, when considered from a surgical standpoint — that is, the definite picture which the surgeon must have in mind at the time of operation — must be viewed from several angles: first, the structures he must pass through before he can reach the kidney; second, the structures he must avoid wounding, if possible, if he is not to cause distressing after-symptoms; and third, the structures that must be watched for and surgically cared for in order to prevent immediate catastrophe during the operation.

To fearlessly and yet carefully perform successful renal surgery is not the outcome of ignorant temerity nor timorous fastidiousness. Very few general surgical operations require such skill and tactile sense, in order to prevent catastrophe at the operating table, as does nephrectomy. In the performance of this operation a clear-cut mental picture must be always before the surgeon because, in almost every complicated case, exigencies arise that demand instant decision and precise manipulation. When trouble does occur, the renal surgeon must understand how to cope with it instantly, and in the presence of such misfortune competent fearlessness is mandatory. He must have a hand of iron in a velvet glove.

As surgery of the kidney is done for diseased kidney, no definite picture of each type of pathology can possibly be described; consequently no definite anatomy can be delineated. In such cases as great hydro- and pyonephrosis the adjacent organs are displaced and adherent in a manner far from normal; in neoplasms sometimes the new growth has extended to the veins and made these structures so friable and brittle that they fracture at the lightest touch; in horseshoe kidney the entire relations of the ureters and vessels are reversed, and so on *ad infinitum.* To the inexperienced, nothing but a description of the normal relations will be of much avail, while to those who have groaned and suffered over difficult cases each step in the discovery of pathology will find a finger-post of experience to point the way.

First: what structures must be passed through before the kidney is reached? The usual incision for renal surgery is the lumbar, as the organs lie close to the back and entirely behind the peritoneum. Hence, most operative procedures can be performed without injuring that important structure.

The first structure is the integument and fascia. As the kidney lies about one-half above and one-half below the twelfth rib and just lateral to the vertebral column, the portion of the skin incised is that beginning at the middle of the last rib and brought obliquely forward toward the iliac crest. When the edges of the incision are laid back and the subcutaneous fat pushed back, the surface of the first layers of important muscles is seen. These muscles are the latissimus dorsi and the external oblique, meeting triangularly with their apex at the top and the crest of the ilium below. In the open space is a fat-covered thick fascia called

Petit's triangle. Below this triangle runs the internal oblique, and when the latissimus is cut through another " surgical triangle " is seen which is bounded by the upper margin of the internal oblique, the last rib, and the serratus posticus inferior. This soft space between the muscles, the " superior lumbar trigonum," lies over the lower portion of the kidney and is its simplest method of access. On the base of this triangle run some fibers of the transversalis, and these must be perforated before the perirenal fascia is reached. On exposure of the transversalis may be seen the XII dorsal and I lumbar nerves. Perforation of this tissue reveals the pararenal fat which is a portion of the extensive layer of fat lying between the perirenal fascia and the muscles of the posterior abdominal wall. Below this fat there is another layer of true perirenal fat surrounded by a thin capsule. When this is incised and retracted, the true renal capsule, closely adherent to the renal structure, is found. These are the structures through which we must pass to reach the kidney.

Second: what structures must be avoided to prevent ill after-results? The only structures to be carefully watched for in this incision are the two nerves before mentioned, XII dorsal and I lumbar, especially the latter. Cutting or seriously injuring this nerve makes for a most uncomfortable anesthesia of the affected side, often extending over the thigh. To consider the other contiguous organs and structures, the kidney must be viewed from the abdominal side. Both kidneys are in their anterior part closely surrounded by the peritoneum, which may be very adherent in some cases and require most careful stripping off. Posteriorly both kidneys lie on the quadratus lumborum muscles and the psoas major and minor.

The right kidney. The blood-vessels supplying the kidney come directly from the aorta and those evacuating the blood pass directly into the vena cava. Consequently, the right renal artery is longer and the right renal vein shorter than its opposite fellow. Sometimes the right renal vein is very short and the proximity of the kidney to the vena cava so great that extreme care must be taken not to injure this important structure in clamping the renal vein prior to removal of the kidney, especially where the vein is very friable due to infection or infiltration. These vessels leave and enter the hilus of the kidney anterior to the pelvis in most part, though some of their branches may pass posteriorly to the pelvis. Separated by the fat and the perirenal fascia and in part by the peritoneum, the right kidney lies in close relation to the liver on its upper surface; the middle portion against hepatic flexure of the colon, and its inner surface against the descending portion of the duodenum and the head of the pancreas.

The left kidney usually lies a little higher than the right. It lies closer to the aorta than the vena cava. Its upper extremity lies against the spleen. Toward its medial section it comes in contact with the curvature of the stomach and below it is close to the splenic flexure of the colon and a terminal portion of the duodenum.

Third: what structures must the surgeon watch for and surgically care for in order to prevent immediate catastrophe during operation?

The most dangerous accident that can occur during renal surgery is injury to the vessels. Not only must the vessels be carefully isolated at the hilium before their connection with the kidney is severed, but the majority of cases requiring nephrectomy present many adhesions about these structures which make their isolation difficult. Injuries to these great vessels produce alarming hemorrhage and, as they retract when cut, their ends are sometimes very difficult to find. Likewise, hasty attempts to grasp these vessels may result in grasping in the forceps some portion of the intestine, especially the curve of the duodenum. Frequently, there are present anomalous and extra vessels passing to other portions of the kidney than the hilus. Two types often occur: (1) upper polar arteries arising from the main vessels or the renal artery; (2) lower polar vessels arising from the main vessels, renal, or iliac arteries. They occur about once in every 190 kidneys examined. These vessels are usually found adherent at their point of entrance to the capsule and demand care by the surgeon in separating every adhesion as any of these adhesions may contain a large vein or artery which can cause alarming hemorrhage.

Lastly, the peritoneum must be considered a structure to be sedulously avoided. Sometimes it is so adherent as to demand incision but more frequently it is accidentally torn. If the opening is not at once recognized, it may easily lead the operator astray and a liver or spleen be delivered into the wound before it is identified. In infectious kidneys with pus, danger of soiling the peritoneal contents is a hazard of much regard. Immediate repair of the peritoneum should preclude all serious results.

The nerves of the kidney enter the structure at the hilus and usually are so small and firm that they bear little surgical importance. Recently, resection of these nerves has been practiced by French and German surgeons, especially for relief of "nephralgia" where demonstrable pathology can not be found.

CERTAIN DISEASES OF THE KIDNEY

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MOVABLE KIDNEY

In considering what is meant by movable kidney, it must be borne in mind that all kidneys are normally movable; that they make a regular excursion with each respiratory movement. The kidney maintains its normal position by a delicately adjusted contact with surrounding structures. It is suspended within a fatty capsule and held in a sort of sack formed by the muscles of the back and the peritoneum. It has no definite suspensory ligaments and floats about with the changes of intra-abdominal pressure. Yet, it has attached to it laterally and below two very definite types of structure, and its relation to these structures, namely its great blood-vessels and its ureter, may be so altered by marked change in its position as to cause not only very painful symptoms but even destruction of the kidney itself. It must be borne in mind also that in an organ so nebulously supported as the kidney, displacement downward is not the only position which may excite pathology and pain, but that torsion may occur and that this rotation is equally as important as ptosis.

The history of movable kidney is erratic because efforts at its correction have followed the age-old medical process of trial and error. The first suspension of the kidney was reported by Hahn in 1881. Attention attracted to this procedure brought on a host of suspensions, the majority of which were done for kidneys that did not need suspending, and it came to be almost a placebo for any lumbar pain where a kidney could be felt or even suspected. The backwash of this wholesale surge of surgery was the casting into disrepute of the procedure because it failed to cure the ills it claimed existed. Only within the past ten years has the diagnosis been put on a scientific basis, and nephropexy now is recognized as a benefit of inestimable value where it is indicated. When, then, is it indicated?

One of the cardinal causes of disease in the urinary tract is interference with the outflow of urine, stasis in the canal. It is certain that many kidneys may be readily palpable even to their upper pole without any interference with the outflow of urine. But when the relations of the kidney to its vessels and ureter become so distorted as to interfere with its nutrition or its outflow, then it seems quite obvious that its position demands correction. This distortion can be definitely determined by the use of the pyelographic fluid and the x-ray. The normal course of the ureter from an undistended pelvis is a straight line, making the flow of urine directly subject to the force of gravity. When distortion of this course occurs, then come the pains of distended pelvis and the pathology of infection and destruction of the kidney. The relation of the kidney and its ureter may be shown in two very definite ways. First, by making a pyelogram in the supine posture and then one in the erect posture. Comparison of these will show whether there is distortion of this normal relation, be it by ptosis or torsion. Second, by studying the emptying time of the renal pelvis. The ordinary pelvis empties in six to eight minutes. Prolongation of this time means stasis. This emptying time is far better studied by pyeloscopy than pyelography. The opaque fluid should be injected and the catheter entirely removed from the ureter so as not to interfere with normal contraction and the emptying of the pelvis, and the ureter viewed and timed with the fluoroscopic screen. Of course, all delays in emptying can not be ascribed to ptosis or torsion of the kidney, but in the presence of a demonstrable distortion of this normal relation, accompanied by the customary concomitant symptoms of pain in the back, gastric disturbance, and sagging sensation, a diagnosis is more than justifiable in the absence of other demonstrable pathology.

The progress of destruction in an obstructed kidney is too well known to merit repetition. One must be on guard to steer a course between the Scylla of presumptive surgery for an unoffending kidney, when the symptoms may be due to the pathology of an appendix or a gall bladder or an ovary, and the Charybdis of a kidney that is gradually becoming infected from back pressure due to obstruction assignable to faulty relation between its pelvis and its ureter. Retention of urine in the pelvis may bring on bacilluria and pyelitis, which magnify the original symptoms and later lead to stone formation and hydro-pyonephrosis. The testimony of collections of large and successful series of nephropexies, which were done not on presumptive evidence but on pyelographic and pyeloscopic study, by Kelley, O'Conor, Thomas, Burford, and many others, attest its unqualified efficiency.

Ptosis of the kidney may or may not be accompanied by visceroptosis. The presence or absence of this complication is not of itself diagnostic nor prognostic, provided the relation of the kidney and its ureter is demonstrably distorted.

The occurrence of movable kidney is commonly assigned much more frequently to females. The ages most usually affected are the third and fourth decades.

The treatment consists in suspension and, what is equally important, partial fixation of the kidney in a position which will restore and maintain normal relation between the kidney pelvis and its ureter. Though there are some twenty-five methods described and heralded, the most generally accepted and practiced is that of Kelley, which consists in passing triangular sutures of silk through the capsule and a slight portion of the cortex and affixing the ends of these sutures to the muscles of the back, and usually passing the upper one over the last rib. Recurrences and complications of those done by this simple method are practically nil. The unsurgical practice of making swings and padding with gauze are best described by the adjective applied.

When complications occur with movable kidneys, they, of course, must be corrected. The commonest of these are stone, hydronephrosis, aberrant vessels, adhesions of the ureter. Some urological surgeons even make a routine of suspending any kidney on which they operate, where the operation requires removal of the kidney from its original bed, as is sometimes necessary in pyelotomy or nephrolithotomy, resection, plication of the pelvis, et cetera.

Nephropexy primarily presumes that the new position of the kidney shall be maintained, not by the sutures or suspension, but by the firmness of the adhesions that are formed. Thus, in order to bring about this adhesion, it is necessary to remove all fat from about the kidney and to fix the new position so that two scarified or raw surfaces are in apposition. This means sometimes rubbing the capsule and the portion of the posterior muscles with gauze in order to make them more likely to form adhesions.

The present case for diagnosis and treatment of movable kidney seems clear. First: a train of symptoms that are suggestive of renal obstruction. Second: x-ray studies with opaque media in the pelvis and ureter, which demonstrate a definite disturbed relation between the pelvis and its ureter and a delay in emptying time of the pelvis. Third: the exclusion of other lesions both renal and extra-renal, such as appendicitis, ovarian disease, gall-bladder infection, mild spinal arthridides, psoas abscess and, urologically, stricture of the ureter and tumors of the kidney.

The beneficial effects of nephropexy done in properly selected cases, with a mortality practically nil, has almost supplanted the wearing of belts with pads as a palliative measure. This is not only an uncomfortable program but, except where some other disease than true renal displacement is present, it is equally as unavailing. The only essential to justify nephropexy is a sustained faith in your diagnosis.

THE "SILENT" KIDNEY

The kidney is an organ placed deeply in the body, and is perhaps as well protected from external influences as any specific organ of the body. If consideration is given to the phylogenetic theory, as exploited by Crile, it is readily seen that it would reasonably be expected that throughout the ages of evolution the reflexes which excite prompt response to injury — that is, those that reply by pain — will be poorly developed in an organ so protected as the kidney. As a result it is found that the greater portion of the kidney is poorly supplied by nerve fibers that respond to any ordinary insults. Most pain that is felt in the kidney is due to distension of the pelvis or the capsule, and is manifested along those nerves which have connection with fibers passing to the skin. For this reason vast destruction and change may occur in the kidney, when there is no obstruction to the urinary or venous outflow, without causing the kidney to cry out, as it were. In the absence of this most promptly heeded of all alarms, the insidious agent of destruction may pursue its nefarious way unsuspected until the kidney is rendered almost functionless.

Practically all diseases which interfere with urinary outflow and cause distension of the capsule or pelvis, announce themselves early and merit investigation. Those that may proceed along quieter lines merit the most careful investigation to prevent error in diagnosis. The great curse of human kind, nephritis — known popularly as " Bright's disease " — may destroy absolutely the function of both kidneys without the slightest pain.

Tuberculosis of the kidney begins usually in the base of a pyramid, a part of the kidney as insensitive to pain as the hair of the head. This disease progresses comparatively slowly and may erode the entire silent portion of the kidney before any manifestation of pain occurs. It is certainly true that practically all cases of tuberculosis of the kidney first seek the aid of the medical profession for the relief of bladder pain. This means that tuberculosis has progressed to a wide destructive process in the kidney before enough of the disease has passed down the ureter to the bladder to cause ulceration and pain. Nor are there always other signs than pain in tuberculosis of the kidney. Pyuria may be slight and hematuria from the erosion wholly absent. Certain cases of tuberculosis so proceed as to close the ureter itself after so great destruction has occurred to the kidney as to render it functionless so far as secretion of urine is concerned, and hence no distension of the pelvis occurs. This process is often entirely painless and is known as " autonephrectomy." Operation on destroyed ureters and kidneys of this type reveals often a ureter as taut as a guitar string, and as useless. Hence it is extremely important to consider always the possibility of tuberculosis in every case of bladder irritability, and search for the possibility of tuberculosis in the kidney.

Calculi usually form first in the calyces or pelvis of the kidney. Should they remain adherent to the mucosa of these structures and never drop down to the uretero-pelvic junction or ureter, so as to cause occlusion and consequent distension of the pelvis, they may grow to enormous size without presenting pain symptoms. Indeed, it is the small, mobile stone that always causes the severe renal pain due to calculus. When the stone remains fixed, it gradually grows, due to deposit of the salts which first occasioned its being, and in its growth, which is necessarily slow, it tends to conform to the hollow portion of the viscus, and smooth-surfaced stones which form a complete cast of the pelvis and calyces may develop unsuspected.

New growths usually originate in that portion of the kidney outside the pelvis. None of the cortical or medullary portion of the kidney is sensitive to either pressure or destructive impressions. It is a recognized fact that renal neoplasms are rarely detected on account of pain and they may advance too far to be amenable to surgery before the least indication of their presence is suspected. When the growth erodes a vessel it may cause hemorrhage or clotted blood, the passage of which down the ureter causes pain, but many neoplasms grow to such size as to be first noticed by accidental palpation by the patient before revealing themselves. Hematuria is probably the initial symptom of 90 per cent. of renal tumors, so that all cases of hematuria, the origin of which is renal, demand investigation. This investigation is best carried out by pyelography, which shows distortion or erosion of the hollow portion of the kidney, in some cases, and by the differential function of the two kidneys, as those which are the site of neoplasm almost universally show diminished function.

Infarct of the kidney is another lesion which is often silent. This occurs by blocking a blood-vessel of the kidney whose terminals are distributed in a wedge-shaped fashion. Unless the infarct be septic, there is little cause for surgical intervention, as little can be done for it, and from that standpoint it has only academic interest; but it does frequently cause a very sudden and sometimes moderately profuse hematuria, and for this reason may be confused with neoplasm. This brings up the subject of " essential " or " idiopathic " hematuria, which clouds the bright pages of urological progress. Any hemorrhage or blood from the kidney denotes some abnormal process, and, because neoplasm is so readily suspected, every available effort must be made to determine positively whether an unexplained hemorrhage is from some benign cause, as infarct, accidental rupture of a small vessel, or nephritis, or whether it results from the malignant type of lesion, as neoplasm, tuberculosis, or calculus. In the benign, no surgery is indicated; but in the malignant, the more promptly the methods of relief are instituted so, by geometrical ratio, is the chance of the patient's recovery enhanced.

Another consideration of silent kidney is that caused by reflex reference of pain. Wherever nerve trunks containing pain fibers supply wide areas, it is well known that stimulation in one part of this body may cause the sensation of pain to be projected to a distant area. This is often seen where pain-causing lesions in one kidney cause the sensation to be referred to its fellow instead. This may result in a perfectly healthy kidney being suspected and its offending fellow being overlooked. Especially is this true in calculus. It is known as the reno-renal reflex.

Other organs are supplied by nerves which may send branches to the kidney and ureter, and especially may the appendix and gall bladder be suspected on the right side and diverticulitis on the left when the kidney itself is at fault. In one large hospital in this country it was found that 25 per cent. of patients presenting right-sided renal and ureteral stones had previously been operated on for appendicitis, and it is justly to be presumed that in the vast majority of these cases symptoms were caused by the demonstrated stone. So it behooves the surgeon to have always in the recess of his mind the possibility of an offending kidney, both when the symptoms point to it and when they do not.

SOLITARY SEROUS CYSTS OF THE KIDNEY

The diagnosis of solitary serous cysts of the kidney, until a few years ago, was considered a rarity. Now it must be considered as a possibility when differentiating any renal tumor. McKim and Smith collected 120 cases appearing in the literature up to the year 1924. Since that time reports of such cases have shown an increasing frequency. Diagnostic criterion has increased to such an extent that a preoperative diagnosis of solitary serous renal cyst is not an unusual occurrence. This condition is not to be confused with the frequently encountered congenital polycystic kidney or the small cysts associated with chronic interstitial nephritis, or the arterio-sclerotic kidney. The condition is seen most frequently in persons of the fourth and fifth decades of life, while two-thirds of the cases have been reported in females.

Pathology. Solitary cysts, as considered under this diagnosis, usually measure 4 c.m. or more in diameter. They are usually unilateral in occurrence, although bilateral involvement has been reported in 4 cases. Most of the cysts are located in the cortex of the kidney, with 6 per cent. at the lower pole, the remainder being either at the upper pole or adjoining the middle calyx. There is apparently no predilection for either kidney. Solitary cysts of this type have received very little attention from the pathologist, but a large number of routine autopsies show them to be present in from 3 to 15 per cent. of cases.

The tissue covering of the cysts shows an epithelial wall which is thinned out, in some respects simulating degenerated renal cortex. The contents are chiefly serous and straw-colored, one typical one, reported by O'Neil, showing alkaline reaction; sp. gr. 1.018; total nitrogen, 202 mgms. per 100 c.c.; sugar 1.10 mgms. per 100 c.c.; NaCl 6.76 mgms. per 100 c.c.; total protein 120 mgms. per 100 c.c.

There is still a lack of agreement among workers in this field as to whether " hemorrhagic cysts " should be included in this classification. Some workers believe that many of those cases described as hemorrhagic cysts may have much in common with the serous cyst and are simply those cases in which some hemorrhage has occurred as a result of rupture of a blood-vessel into the serous sac.

Pathogenesis. Owing to the fact that practically all the cysts are demonstrated in late adult life and manifest themselves chiefly by the presence of a mass, their true origin is in doubt. Albarran's suggestion that the disease may be somewhat akin to the polycystic kidney is supported by so little evidence that it can only assume the proportions of a suggestion. Several theories have been advanced as to their origin, namely:

(*a*) They may be embryonic rests proliferating under the influence of extreme causes. Their contents and pathological findings lend nothing to substantiate this theory.

(*b*) Failure of union of tubules and glomeruli, resulting in a retained secretion.

(*c*) Retention or inflammatory cysts, due to constriction of tubules by fibrous tissue or blocking of the glomeruli or tubules by desquamated and degenerated cells.

(*d*) Recently Kampmeier has suggested they are due to the persistence and expansion of cystic tubules which have failed to collapse. None of these theories has much well-founded support.

Symptomatology. Preliminary examination of these patients is usually the result of finding a mass in the abdomen or symptoms referable to pressure from the mass. There may be a sense of fulness or dragging in the lumbar region. Usually there are no urinary symptoms or findings. Gastro-intestinal symptoms predominate in some cases, due to displacement of the various parts by the mass. There is an absence of hematuria, which aids in differentiating them from malignant neoplasm. Pain in the back is a common complaint, often radiating to the groin. The pain is generally intermittent in character, aggravated by such factors as childbirth, exercise, et cetera, but never colicky in nature. Due to the weight of the tumor, causing a prolapse of the kidney, numerous diagnoses of ovarian cyst have been made.

Diagnosis. Differential diagnosis must be made from all the causes of a mass in the upper abdomen, and is accomplished chiefly by exclusion and pyelography. Blood chemistry is unchanged. Pyelography, done stereoscopically, may give a definite idea of the relation of the mass to the kidney and prove its connection.

Pyelography may reveal one of six findings with solitary serous cysts, namely: a normal pelvis, hydronephrosis, compression of a calyx or the true pelvis, changes in the position or axis of the kidney, or, lastly, an outline of the shadow of the cyst or calcification of the cyst wall may be demonstrated.

The pyelogram may be normal if the cyst does not impinge on the pelvis or one of its calyces. Rarely does this happen because, if the cyst is large enough to give pressure symptoms, it is more than likely to distort the pyelogram. Distortion of the pyelogram may be due to a small cyst located near the pelvis and pressing early upon a calyx.

Hydronephrosis is usually due to a cyst of varying size in the lower pole of the kidney so located as to obstruct the ureter. It is difficult in these cases to detect any possible distortion of the pelvis in the presence of a concurrent hydronephrosis which would tend to mask it.

Compression of the pelvis or nearest calyx is the most frequently observed feature of these pyelograms. Any one or all of the calyces may be involved. With more pressure, retraction of the calyces is seen and is one of the more common findings. Flattening of the pelvis without changes in the calyces may occur if the cyst arises on the mesial border. A change in the position and axis of the kidney may result as one of the diagnostic features of these pyelograms, as pointed out by Braasch, due to increased weight on one pole, twisting the kidney on itself.

Improvement in modern roentgenographic technic has increased the number of cysts visualized, due to the difference in density between the cyst and surrounding organs.

The shadow produced by calcification of the cyst is an interesting but less common finding.

Ormand added an important diagnostic feature when he demonstrated that pressure on the tumor mass moved the kidney pelvis in a like direction.

Thus, the diagnosis of solitary serous cysts of the kidney depends upon the finding of a tumor mass in the abdomen, absence of urinary symptoms and findings, pyelographic evidence, and the exclusion of other possible causes for the tumor mass.

Treatment. The treatment of this condition is entirely surgical. Resection of a wedge-shaped portion of renal tissue with the cyst is the ideal treatment. The cyst is characteristically attached firmly to the adjoining parenchyma and can seldom be shelled from its bed. Tearing dissection is crude at best and is more likely to be followed by secondary hemorrhage than is the removal of a portion of the kidney with the cyst wall and the bringing together of the resulting V-shaped defect by mattress sutures.

If the growth is large or multiple and if resection should necessitate too great a loss of renal tissue, the cyst may be cut off flush with the renal border and its base cauterized. Following either of these procedures, the kidney should be sutured in its normal position to prevent displacement into the resulting cavity left by the removal of a large cyst. Nephrectomy has frequently been utilized in the past, but unless an associated malignant condition is suspected, or parenchymatous damage is too great, more conservative surgery is indicated.

The operative approach for these cases may be through the classical lumbar incision, but difficulty may be experienced in delivering one of the large cysts intact through such an incision. The transperitoneal approach is well adapted to this type of case because of the more adequate exposure and lessened danger of infection and peritoneal tumor transplants in these cases.

ECHINOCOCCUS OR HYDATID CYSTS

Echinococcus infestation, or hydatid disease, occurs very rarely, its greatest occurrence being in those localities which are largely devoted to agriculture, such as Australia, New Zealand, Argentine, Iceland, Southern Europe, and Northern Africa. Strict public health measures in Australia and Iceland have markedly reduced its incidence in man. The infection is more common among men, because of their more frequent contact with infected animals. The age incidence may be from the first to the sixth decades of life.

Even though hydatid disease is rare, kidney infestation is even rarer. This is due to the fact that the invading parasites, after penetrating the intestinal wall, enter the portal circulation, the liver filtering out a large percentage, as shown by the statistics (65 per cent.). Before reaching the kidneys, the blood carrying these parasites must traverse the liver, heart, lungs, and back again to the heart, thereby leaving only a 2 per cent. chance of infesting the kidney. The relative frequency for the site of infestation of various organs according to Cinozzi is as follows:

Liver	65 per cent.
Lungs	16 “ “
Spleen	8 “ “
Mesentery	4 “ “
Kidney	2 “ “
Pelvic Organs	2 “ “
Muscles	1 “ “

The tænia echinococcus requires two hosts to complete its life cycle: man and some carnivorous domestic animal, as the dog. The parasite is found most commonly in the duodenum of the dog. In this stage it is about 4 mm. in length and is composed of only a few segments. It fastens itself to the mucous membrane by means of hooklets or suckers. This stage has never been found in man. The last segment of the worm, which is known as the proglottis, contains as many as five thousand ova when mature. This segment is periodically cast off and expelled in the feces. Through the contamination of vegetables eaten raw and drinking water, the ova find their way to the gastro-intestinal tract of man.

The development of the cysticercus stage is very slow. The acid secretions of the stomach tend to retard the development of the ova, but at the same time dissolve the enveloping membrane. As soon as the ova reach the intestine, the embryos are freed, possibly from the action of the bile. Each six-hooked embryo attaches itself to the intestinal wall, penetrates it, and eventually enters the portal circulation. Passing through the liver, the majority of embryos are filtered out and, secondarily, by the lungs. Upon reaching their final destination, the six-hooked embryo disappears and a vesicular worm develops, surrounded by a pericystic membrane, which represents the normal reaction of inflammation of the organ to an invading host. It is therefore correct to speak of the invading host as having two layers — a capsule and an endocyst. This constitutes the second or encysted stage of the infestation. In the primary or mother vesicle, daughter vesicles, or cysts, develop. If the daughter cysts grow, the walls of the mother cysts are distended by means of herniated sacs which may rupture, freeing the contents, and thus the cycle is completed in man.

Since the cysticercus stage in man is extremely slow, symptomatic manifestations may not appear for 18 to 24 months after the six-hooked embryo becomes attached in the lung.

Although the vast majority of cases are reported in the foreign literature, Mills has collected 14 cases in children living in North America.

Classification. The symptomatology, diagnosis, and treatment depend upon the class in which the cyst falls. The classification of Craig and Lee-Brown seems to be the most satisfactory, it being as follows:

$$\text{Open and closed hydatid}\left\{\begin{array}{l}\text{Active living.}\\ \text{Calcified living and dead.}\\ \text{Infected living and dead.}\end{array}\right.$$

Symptomatology. *Closed hydatid cyst symptoms.* The symptoms in these cases are those in renal tumor only. By a "closed hydatid cyst" we mean a cyst which has not ruptured into a calyx. The patient in these cases complains of a sense of dragging or discomfort in the flank, aggravated by exercise. Diaphragmatic pleurisy or local peritonitis may develop if attachment to surrounding tissues occurs. The general health of the patient is unimpaired. A low grade hematuria may occur in 50 per cent. of the cases. Hematuria evidently results from the irritation, edema, and congestion of the mucous membrane of the kidney pelvis caused by the pressure of the tumor.

Open hydatid cyst. These cysts have ruptured into the kidney pelvis, discharging a large number of pieces of hydatid debris into the kidney pelvis and ureter. The patient complains of having passed "grape skins" which are in reality pieces of the cyst lining and daughter cysts themselves. This finding is absolutely diagnostic of hydatid disease. The passage of these pieces of debris may give rise to renal colic, associated with hematuria. These symptoms may clear up, and the patient will be perfectly well for several weeks or months. Once the cyst has ruptured, the cavity becomes secondarily infected. No cases have been reported that were infected previous to rupture.

Calcified hydatid cysts as a rule produce no symptoms and are discovered only in routine urological examination. A fully calcified cyst is a dead cyst and, unless it causes symptoms, should be left alone. A calcified hydatid cyst of the open type may cause symptoms of renal colic from the passage down the ureter of calcified debris.

Cystoscopic examination shows a turbid efflux from the involved side during an attack of hematuria. The mucous membrane of the bladder is rarely involved even in the infected open cysts.

Bladder urine obtained in the open type of cysts will show, besides red blood cells and pus cells, numerous hydatid hooklets and pieces of chitinous laminated hydatid membrane. Nothing else resembles these findings, and they are absolutely diagnostic.

Functional tests of the kidneys with phenolsulphonephthalein reveals no difference, unless there is complete destruction of one kidney, in which case there is a total lack of function of the involved side.

Pyelography is of great value when a positive deformity is present, in which case it will show the presence of renal tumor and localize its position. The absence of a deformity does not necessarily rule out the disease. Cysts lying in the periphery of the cortex tend to expand radially, thus not exerting pressure on the calyces.

On pyelographic evidence there should be little difficulty in differentiating a hydatid from a solid tumor, the latter causing more spider-like deformity than a hydatid of the same size. Hydatid and solitary cysts cannot be differentiated by pyelographic evidence.

Laboratory Tests. The blood count in hydatid disease is diagnostic only in so far as we get an increase in the eosinophiles up to 10–20 per cent. in 50 per cent. of the cases observed. Eosinophilia is absent in cases of calcified dead cysts. Serological reactions have greatly increased the percentage of correct preoperative diagnosis. Of the sero-diagnostic tests, the complement-fixation test of Bordet Gengon is positive in 93 per cent. of echinococcus cases. This is only true when an expert technician is available. According to Cinozzi, the intradermal reaction of Casoni is positive in 90 per cent. of cases. Other less reliable tests are:

1. The precipitin test.
2. Myostagmin reaction.
3. Anaphylactic reaction.

Diagnostic puncture of a cyst is a dangerous procedure to carry out. Escaping fluid may result in a severe anaphylactic shock, or daughter cysts may escape retroperitoneally and proliferate in uninfested tissue.

Diagnosis. The diagnosis may be suspected from a history of fulness and dragging sensation in the loin, associated with a palpable renal tumor. The open type should be easily diagnosed from the urinary findings of hematuria, "grape-skins," and scolices. The closed type represents a more difficult problem, but a high degree of accuracy should be obtained with the additional aid of pyelography, the presence of eosiniphilia, and a positive sero-diagnostic test. Occasionally we may obtain the classical "thrill" during palpation, resulting from the rubbing together of the daughter cysts.

Treatment. The recognition of the fact that these are the two types of cysts — the open and the closed — helps to rationalize the treatment, which is entirely surgical. The closed type of cyst, which is never infected, is usually approached through the classical lumbar incision. The cyst is delivered through the incision as far as possible. A needle is thrust into the cyst and a moderate amount of fluid withdrawn. Alcohol is then injected to replace the fluid, and a short interval — three to five minutes — is allowed to elapse, to devitalize the parasites. The cyst is then firmly packed around with dark-colored sponges, to detect any escaping contents, and the cyst laid open. The edges of the cyst are usually fixed to the muscle edges. The cyst is then thoroughly cleaned out with a curet. The cavity is again swabbed out with alcohol. The cyst is left open but the abdominal wall is closed in layers, leaving a small rubber dam drain in the incision but not extending into the cyst. The drain is removed in three or four days, if all goes well. Large rubber tube drains are used only when the cyst communicates with the liver or spleen.

The two-stage operation, designed to wall off secondary infestation, is rather ultra-conservative and is seldom used.

The open type cyst is always secondarily infected. Any such procedures outlined for the marsupialization of a closed cyst would be impractical in the open type, since it would result in a permanently infected urinary fistula through the wound. The classical nephrectomy is the operation of choice in the open type and should be performed without any more difficulty than for any other disease of the kidney.

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OPERATIVE AND NON-OPERATIVE TREATMENT OF THE KIDNEY

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OPERATIVE AND NON-OPERATIVE TREATMENT OF THE KIDNEY

Renal surgery is a comparatively modern branch of medical art. Not until after the introduction of anesthesia, and the general adoption of the principles of asepsis in surgical procedures did it become possible to intervene successfully upon the human kidney. Even then our knowledge of the workings of the renal system and of kidney pathology generally was still so restricted that the surgeon was unable to deal with disease seated in that region with anything like the confidence and mastery of detail he had attained in other lines of his special work. The first quarter of the twentieth century was an epoch of unparalleled progress, the most conspicuous advances being the application of renal functional tests and the use of injections of opaque media, making possible the visualization of the urinary tract by means of X-rays.

These two procedures, together with a host of valuable, if less important, diagnostic measures, have placed us today in a position to ascertain the condition of the kidneys before making any attempt to treat them surgically. Renal surgery has thus been made safer and more satisfactory than was heretofore thought possible. At the same time its employment has been, in a measure, restricted because at present we are in so much better position to tell when it is unnecessary or undesirable. This brings us to the seeming paradox of non-operative measures taking their place in a treatise on operature procedures. Knowing when *not* to operate becomes of equal importance with a knowledge of operative technique.

GENERAL CONSIDERATIONS IN RENAL SURGERY

Selection of patients. Pathologic conditions in the kidney are manifested chiefly by pain and abnormalities in the urine. Unfortunately for the diagnostician these symptoms are common to practically every disturbance which occurs in the urinary tract, so before the blame can be fixed upon the kidney a very careful scrutiny of the entire urogenital tract will be in order. Urinalysis alone will tell us little or nothing. In conjunction with the findings from such physical measures as palpation and percussion, the results of cystoscopic observation, and the revelations of the Roentgen ray it becomes a most valuable diagnostic procedure.

Again, examination of the bladder urine alone gives only vague information. When separation of the output of each ureter has been accomplished through catheterization of both sides the isolated specimens will tell a tale full of diagnostic importance.

As we are dealing here only with renal surgery no description will be given of those general procedures by means of which we are led to suspect that our patient's particular difficulty arises in the kidney region. Once the kidney has fallen under suspicion we have a number of avenues open to us by which this may be confirmed or proved unfounded.

Palpation and percussion. Our medical forebears relied chiefly upon palpation and percussion as they did not enjoy the wide range of diagnostic procedure which is now open to us. They rightly believed that a palpable kidney is a sick kidney, or if not actually pathologic at least abnormal, and very likely indicative of disease of its fellow. The experienced examiner can learn a good deal by these " old fashioned " procedures, which should never be neglected no matter how many laboratory and roentgenologic examinations we may make in addition.

With the patient in the dorsal position, all the abdominal muscles relaxed as completely as possible and the knees flexed, the examiner should place one hand beneath the back, and the other upon the abdominal wall directly over it. The lower hand presses upward between the twelfth rib and the iliac crest, while the upper hand bears downward directly upon the abdominal wall. The patient may also be placed upon the side opposite the one to be examined, with his knees drawn up. Palpation will be of no value unless it is bimanual and variations from the positions just described are not likely to yield any greater amount of information. Correct bi-manual palpation will usually indicate the existence of enlargement of the kidney due to calculus, pyo- or hydronephrosis, or tumor. In the same way one may become aware of the contraction or spasm of the muscles which is characteristic of several kidney conditions, while the rigid muscular defense which often presents itself will also be detected. If such muscular rigidity is manifested, particular attention should be directed toward the region of the quadratus lumborum muscle. In any attempt to diagnose renal disease by palpation this area should not be neglected, for there will be found evidence which a more general examination would not bring to light. Acute inflammation will be suggested if there is general tenderness over the lumbar region, especially noticeable in the neighborhood of the tenth, eleventh and twelfth ribs and the costovertebral space.

Differential diagnosis. An enlarged kidney cannot always be told from an adrenal or retroperitoneal tumor. It should be remembered that the kidney lies further to the side than pancreas, gall-bladder or left lobe of the liver. This will aid in distinguishing renal growths from those in neighboring organs. Lumbar palpation will frequently assist in establishing this differentiation. It is performed as follows:

The examiner sits at the right side of the table, the patient lying close to the edge. The examiner's left hand should be pressed upon the costolumbar angle, while his right rests on the antero-lateral abdominal wall, directed upward a little beyond the *linea semilunaris*, the finger tips reaching to a point just below the free border of the ribs. The patient now inhales deeply, giving the examining right hand an opportunity to press downward firmly as the abdominal wall relaxes between inspirations.

Renal balottement. In some cases where this procedure fails to make a suspected kidney palpable the *renal balottement* of the French urologists may be elicited by giving a sharp tap with the left hand to the lumbar wall. The palpating right hand may thus get a sensation not unlike that known as *fœtal ballottement*, which is imparted to it when the tap of the left fingers from behind causes a mass within the abdominal cavity to come in contact with it. At the first attempt the patient should breathe normally; a second time he breathes heavily and the maneuver is repeated as inspiration ends and relaxation of the abdominal wall takes place. This measure is useful in conjunction with other means but alone will not differentiate a tumor from a mass of tubercular caseation or even from an enlarged lobe of the liver.

Detection of " floating kidney." Movable kidney can usually be detected by palpation and percussion. By the ordinary bimanual procedure it can be outlined, and its size, shape, and range of motion detected with a fair degree of accuracy.

Cystoscopy. The first instrumental aid in making renal diagnosis was the cystoscope which has now rounded out a full half-century of usefulness. Inspection of the bladder often gives conclusive information regarding the state of the kidneys which supply it with its urine content. In early cases of renal tuberculosis there may be no more than a slight edema about the orifice of the ureter of the affected side, yet the urine will spurt from it more frequently than is normal, and the fluid itself will appear cloudy and discolored. In advanced cases the condition of the bladder will at once indicate what one may expect to find in the kidney, as cystitis is the most characteristic manifestation of advanced renal tuberculosis.

Other renal lesions are not so easily indicated by mere inspection of the ureteral orifices, and in most cases catheterization of both sides is necessary, and is readily accomplished through the improved types of operating cystoscope. The orifices are located through the telescope, and the catheter for the side to be first examined brought into the field of vision and inserted. With improved technique it is now possible to catheterize both sides simultaneously, but often this is unnecessary. Ureteral catheterization is primarily used to obtain separate specimens of urine from each kidney, but its value to the renal surgeon is by no means limited to this. Pathologic conditions in the ureter such as kinks, strictures and calculi, may be demonstrated when catheterization is undertaken, and there are many cases on record where grave urinary tract symptoms have absolutely disappeared after a single catheterization which had as its object the discovery — and not at all the cure — of a suspected lesion. The hydronephrotic or pyonephrotic kidney is frequently emptied by this means, and it serves to provide numerous diagnostic sidelights otherwise impossible to obtain.

Tests of renal function. The estimation of renal function in each kidney separately is of great importance when any surgical procedure is contemplated, but it is of particular value when nephrectomy is under consideration. The test now most often employed is that devised by Rowntree and Geraghty, which consists in injecting phenol-sulphonephthalein into the muscles of the arm or intravenously. After emptying the bladder and passing the ureteral catheters to the pelvis on either side, the patient is given 300 cc. of water by mouth. From 60 to 85 per cent. of the amount of dye used will be excreted by the normal kidney in two hours. The percentage is very easily determined by the use of a colorimeter. The amount of the drug secreted does not correspond to the volume of the urine. Though the quantity of urine be normal, the permeability of the drug may be much diminished in proportion to the intensity of the kidney mischief. Thus even in cases of nephritis where uremia is threatening, or in eclampsia the volume of the urinary output may equal the normal.

Value of the test. The test of renal function is perhaps the most valuable diagnostic measure unrelated to others, which we now possess. Though its findings are very dependable its worth is much enhanced by comparison and conjunction with others. The injection of dyes serves other purposes than that of estimating function. For example, in an inflamed tuberculous bladder it may be impossible to locate the ureteral orifices, but intravenous injection of such a dye as indigo carmine will shortly color the urine so that its point of entrance into a bladder filled with clear water can immediately be noted. There are numerous other tests which have been employed for estimating renal function but they are now largely discarded in favor of the 'phthalein test, which surpasses them all in simplicity and efficiency.

BLOOD CHEMISTRY

The development of chemistry of the blood has proved of great diagnostic value in many urologic conditions and now gives us some of our most valuable data in regard to renal function. The estimation of the urea, non-protein nitrogen and creatinin of the blood of a patient suffering from some form of renal impairment now takes rank as a diagnostic procedure of major importance.

Urea estimation. The urea content of the blood varies considerably under entirely normal conditions. From 20 to 40 mg. per hundred cubic centimeters may be taken as a normal range, and for those upon a high protein diet, 50 mg. need not be regarded as beyond normal limits. It becomes necessary to consider the personal equation in every case. Where the protein intake is low and the urea is as high as 50 mg. it would be indicative of abnormal urea retention. The amount of water ingested may also have an influence upon the urea readings. Many observers have noted that high blood urea will be reduced following a large fluid intake. The amount of urea excreted varies with the urine output. This is especially true when the pathological condition in the kidney has not advanced very far.

If the amount of urea in the blood is shown to be much above normal, it indicates the existence of a certain amount of bilateral renal insufficiency. If it rises to over 100 mg. it must be regarded as a very serious symptom. In acute renal disease a far higher level is often reached with subsequent complete recovery. Frontz and Geraghty have seen the urea rise to 250 mg. in cases of acute suppuration of the kidneys with oliguria or anuria, followed by return of the urea to normal and complete recovery. But they state that such figures are seldom attained in chronic renal conditions, and if they are, the case always terminates fatally.

Creatinin estimation. While the amount of urea present when a certain specimen of blood is examined may be lowered because the patient has just drunk a considerable quantity of water (previous to the obtaining of the specimen) this is not true of the blood's creatinin content. Squier and Myers found that creatinin is more readily excreted than is urea or uric acid. Therefore there can be a considerable diminution in renal function before there is any appreciable rise in the creatinin level in the blood. Normally creatinin is found in the blood in a proportion of about 2 mg. per 100 ccm. If there is any marked rise above this, to 5 mg. or over, serious renal impairment is indicated. If the blood urea is also high the prognosis is still more grave. Creatinin values must always be considered in relation to blood urea, the values of which have been obtained at the same time. It may be taken as a rule that creatinin is not retained in the blood until the impairment of the kidneys is such that function is markedly interfered with and urea retention greatly increased. As Kilduffe has succinctly put it: Creatinin values of 2.5 to 3 mg. per 100 ccm. are suspicious; 3 to 5 mg. per 100 ccm. of unfavorable import; while over 5 mg. per 100 ccm. means as a rule, an early fatal termination. Exceptions to this are *anuria* in which, if we find and remove the cause, creatinin retention is not especially significant; and *acute nephritis* during the course of which creatinin values may rise very high for a brief period, quickly subsiding, and the outcome eventually be favorable.

Uric acid estimation. As Myers has remarked, the kidneys could hardly be expected to eliminate the various nitrogenous waste products with equal readiness. The difference between the ability to excrete uric acid on the one hand and urea and creatinin on the other is shown when we compare the concentration of these substances under normal conditions in the blood and urine. Viewed thus, it will be found that the kidneys normally concentrate the creatinin about 100 times, the urea 80 times, but the uric acid only 20 times. As the permeability of the kidneys is lowered in renal disease evidences of this can be obtained by blood analysis. There will first be retention of uric acid, later of urea, and lastly of creatinin, indicating that creatinin is the most easily eliminated of these three nitrogenous waste products, and uric acid the most difficult.

Examination of the blood of healthy adults shows that uric acid may vary from 1 to 3.8 mgm. per 100 cc. of blood. Dietary factors, no doubt, have a considerable influence upon these findings. Very high uric acid values are found in the last stages of chronic nephritis, and Myers and his co-workers called attention a number of years ago to the finding of high values early in this disease, before either urea or creatinin retention has had time to take place. This led them to advance those uric acid findings as early evidence of impaired renal function. Some years later Baumann and his collaborators called it the most delicate index of renal function now available to us.

Relative value of the different determinations. Inasmuch as the level of the blood urea is influenced when renal impairment is still very slight, it is apparent that the urea concentration test is the most valuable single procedure affording a measure of renal efficiency. In cases of advanced nephritis, the creatinin estimation is worth more than is that of urea, as it is only when renal function is greatly impaired that its retention begins. As uric acid is the most difficult of elimination of the three substances under consideration, a rise in the uric acid in the blood takes place before that in urea content. Yet on the whole, uric acid retention is less reliable as an evidence of impaired renal function.

Blood chemistry and urinalysis compared. Blood chemistry has already proved an invaluable aid in all pathologic conditions of the kidneys, but its employment in no way lessens the value of urinalysis. By determining the character and amount of the urinary content, the presence or absence of certain normal and abnormal constituents, we find out what the kidney is *excreting*. Blood chemistry, by revealing the presence or absence of certain constituents in the blood, shows us what the kidney is *retaining*. Examination of the urine shows what the kidney is doing; blood chemistry shows what it is leaving undone. Both of these diagnostic procedures must be frequently repeated to be of value. Day by day changes constantly occur. Frequent observation alone will permit the clinician to recognize and deal with them satisfactorily.

RENAL ROENTGENOGRAPHY

Pyelography is the title given to that roentgenologic procedure which consists of injecting the ureters and kidney pelves with some fluid opaque to the Roentgen rays. These structures will then appear outlined in subsequently taken roentgenograms. *Pyeloscopy* is the examination of the kidney and ureter through the fluoroscope during and after the injection of such an opaque medium. By *stereoscopy* or *stereoskiagraphy* is meant the employment of stereoscopic roentgen-ray films in the making of ureterograms. For this opaque ureteral catheters are generally employed in place of fluid media. The value of these roentgenographic procedures is not considered great by Braasch, but Waters speaks of the " splendid results " to be obtained, showing the size and character of calculi, the shape of the renal pelvis and its calyces, and other conditions not likely to be brought out in flat views. Special apparatus must be employed to get the best stereoscopic results in urographic work.

Pyelography. For many years pyelography was very limited in its application because the only available pyelographic media were more or less toxic. Severe injury to the urinary tract, or even death, sometimes followed its employment. This limitation was relieved to some extent by the use of opaque catheters, and later the introduction of sodium iodide as a medium did away with most of the objections. In carefully selected cases pyelography is now practically without danger if carried out by competent hands. Yet it still remains a fairly severe ordeal and no patient who is cachectic or suffering from severe and acute renal inflammation should ever be subjected to it. For this reason it is reserved until the last, and is only applied when renal function tests and ureteral catheterization combined with blood chemistry have given enough information concerning the condition of the kidney to make a competent observer feel safe in carrying it out. The recent introduction of Uroselectan will in the future make the occasions for using the injection method still less frequent.

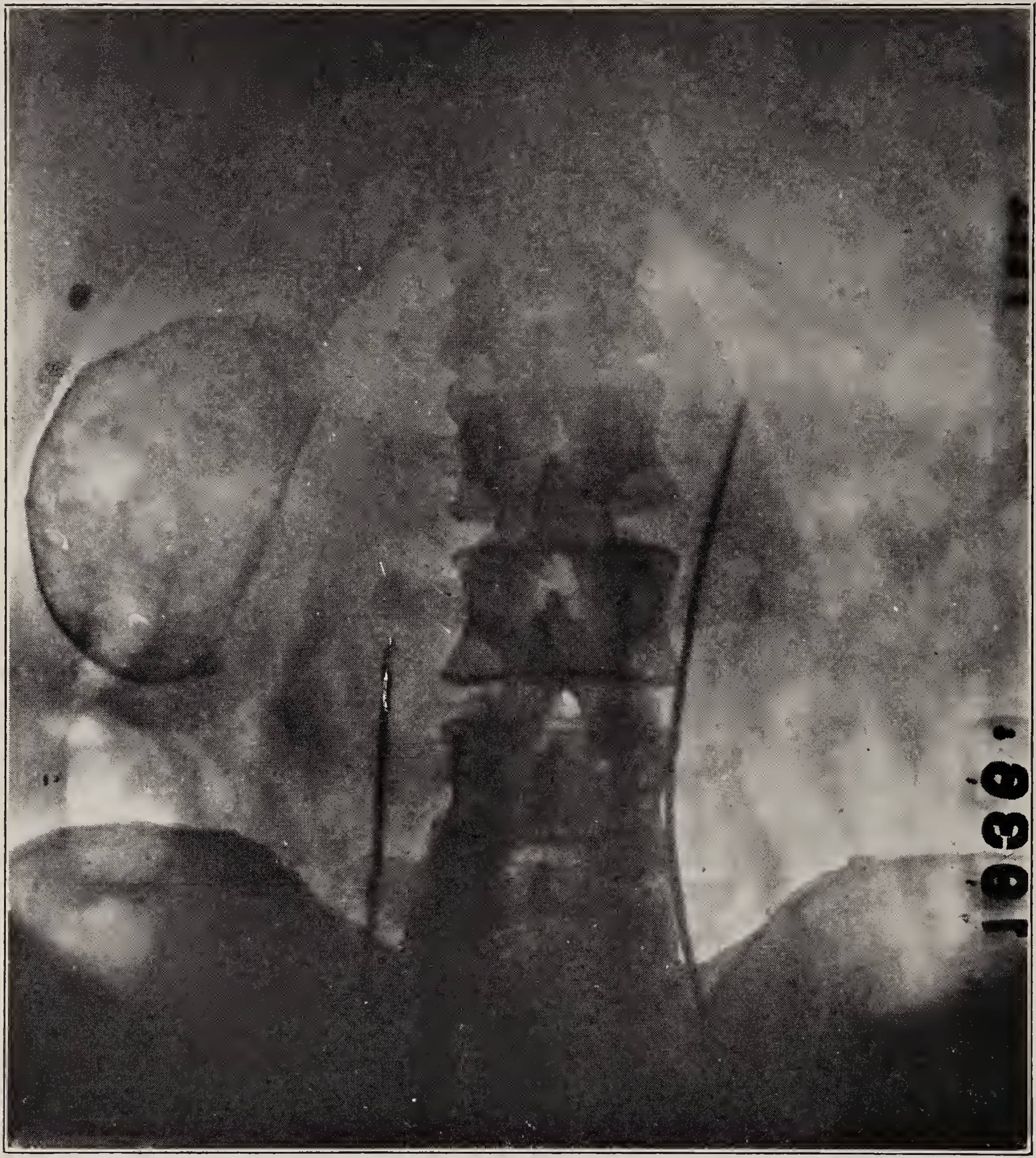

FIG. I. Plain roentgenogram, showing findings in case of calcified solitary cyst of the kidney (Lowsley & Kirwin's *Textbook of Urology*. Courtesy of Lea & Febiger, Publishers).

Preliminary x-ray examination. Before injecting the ureters it is customary to have several exposures made of the renal region, as in this way calculi, tumor masses or anything else capable of casting a shadow may be located before the more minute examination of the calyces is carried out. Shadows are frequently seen which can only be interpreted by the further elucidations of pyelography, but the plain roentgenogram is of value in determining the kidney outlines and location. In not a few cases what has been diagnosed as a renal lesion has in this way been proved to be seated in a wholly different organ, quite unrelated to the kidney.

Interpretation of pyelographic findings. Sodium iodide has proved perfectly satisfactory for all the pyelographic work the author has been concerned in, up to the introduction of Uroselectan, and it is doubtful if we shall have need to seek further for a medium when the injection method must be employed. It is important to withdraw the opaque medium as soon as the roentgenographic work is completed. This is invariably our practice and the following of this routine has undoubtedly spared us many of the ill effects which have been reported from other quarters.

The technique consists in passing the cystoscope and examining the bladder, if this has not already been done at a previous examination. The ureteral orifices are then located and lead catheters inserted into them. The catheters are passed if possible to the pelves on either side. Specimens of urine from each side separately are secured for laboratory examination, unless this has also been previously attended to. The 'phthalein test is then performed. Following this plain roentgenograms of kidney and ureteral regions are made. Next 15 to 20 per cent. solution of sodium iodide is injected by a specially designed syringe. The injection is continued very slowly until the patient complains of a sensation of ' fullness ' in the back. This indicates sufficient distension of the kidney pelvis and a radiogram taken at this juncture will give a clear outline of this portion of the urinary tract.

Measurement of pelvic capacity. A wise precaution is the preliminary injection of from 5 to 8 cc. of normal salt solution into the kidney pelvis — the patient being instructed to mention the first sensation undergone — usually a slight dull ache. The amount of saline injected up to that time should be carefully noted and the fluid withdrawn. This will afford a very close measure of the capacity of that particular pelvis. After a five-minute interval the injection of sodium iodide may be begun, about 7 cc. being drawn up into the syringe. It should not be forgotten that some patients have considerable fortitude and will not complain until too much solution has been allowed to run in, risking an overdistention of the renal pelvis.

Unnecessary pyelography. Since this procedure has been rendered relatively innocuous there has been a tendency on the part of many urologists to use it very frequently. This is a mistake. The physician should not let his eagerness to visualize his case as clearly as possible, blind him to the inconvenience and possible injury which may be imposed upon his patient. In Germany it is customary to give an intravenous in-

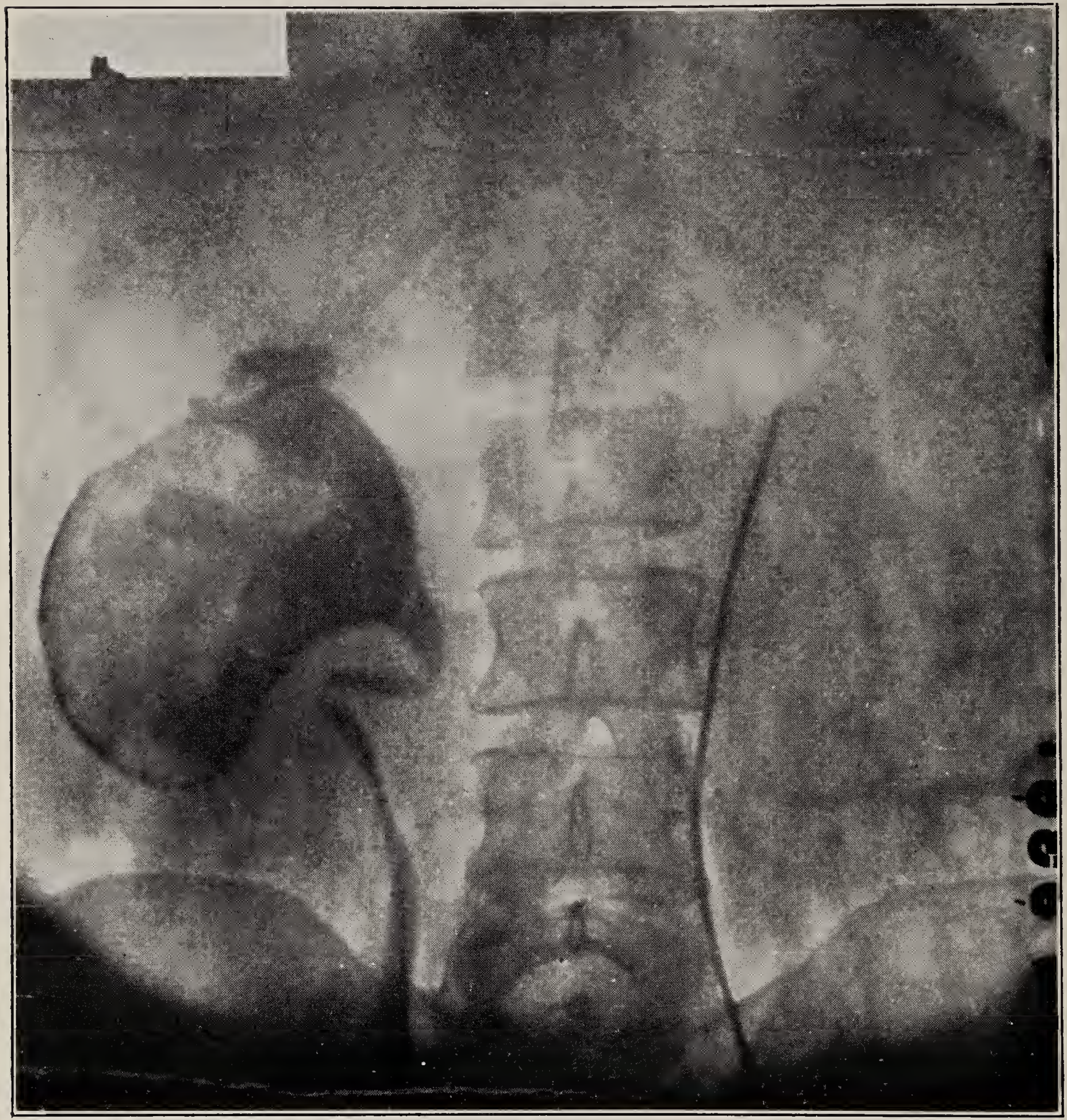

Fig. II. Value of ureterogram in diagnosis. Same case as Fig. I after pyelography. Cyst plainly visible held in grasp of renal pelvis, while below two ureteral kinks are clearly demonstrated, one at the junction of ureter and pelvis, the second about 3 cm. further down. (*Textbook of Urology.*)

jection of indigo-carmine (known in this country as Thomas's method) and wait for the appearance of the dye at the ureteral orifices. A pyelogram is made only on the side that shows delayed function. Yet it must be taken into account that under certain conditions a very badly damaged kidney may, when subjected to such a test, give a normal appearance time. In some tuberculous cases for example, where a walled-off hydronephrosis exists, the dye will appear quite as promptly upon the diseased as upon the sound side — sometimes a trifle sooner. Under these conditions all the data obtained will have to be considered together. Often a careful comparison of plain roentgenograms and one-sided pyelograms will give sufficient information without resorting to double pyelography, which should be avoided whenever possible.

Ureterograms. When it is desirable to study the contour of the ureter the procedure is similar to that followed in pyelography. With the tip of the ureteral catheter passed entirely through the duct to the pelvis, the opaque medium will not, as a rule, flow back down the ureter. But if the catheter be then withdrawn into the distal portion of the ureter, the examiner will be able to obtain a good outline of the ureter at the same time the pelvis is done. Waters cautions that in the interpretation of a ureterogram it must be remembered that peristalsis is going on, and waves of contraction will often be seen on the films made of normal ureters. Such contractures are often interpreted as strictures. Again, the movement of the ureter filled with opaque solution during the time of exposure may give a much wider shadow than is justified by the conditions actually present. This may lead to an erroneous diagnosis of ureteral dilatation. Curves or kinks in the ureter may at certain angles give pictures suggestive of far more acute angles than actually exist. Stereoscopic views are of value here. Braasch finds that the elasticity of the ureter's walls and the technical difficulties in the way of complete filling with opaque medium frequently make it impossible to demonstrate its entire outline. Incomplete distention may make its contour more or less irregular. Points of narrowing may be exaggerated either by incomplete distention or by spasmodic contracture. The course of the normal ureter is usually fairly uniform unless it is altered by pressure, by a rigid ureteral catheter, or as the result of renal mobility. Incomplete distention of the ureter occurs so frequently that an existing dilatation may be easily overlooked. To obviate this, Braasch recommends the use of a No. 9 catheter, placing the patient in the modified Trendelenberg position while making the injection into the ureter. Complete distention can sometimes be accomplished by inserting two catheters, one in the pelvis and one in the lower ureter, making injections simultaneously into each. Again, angulation of the

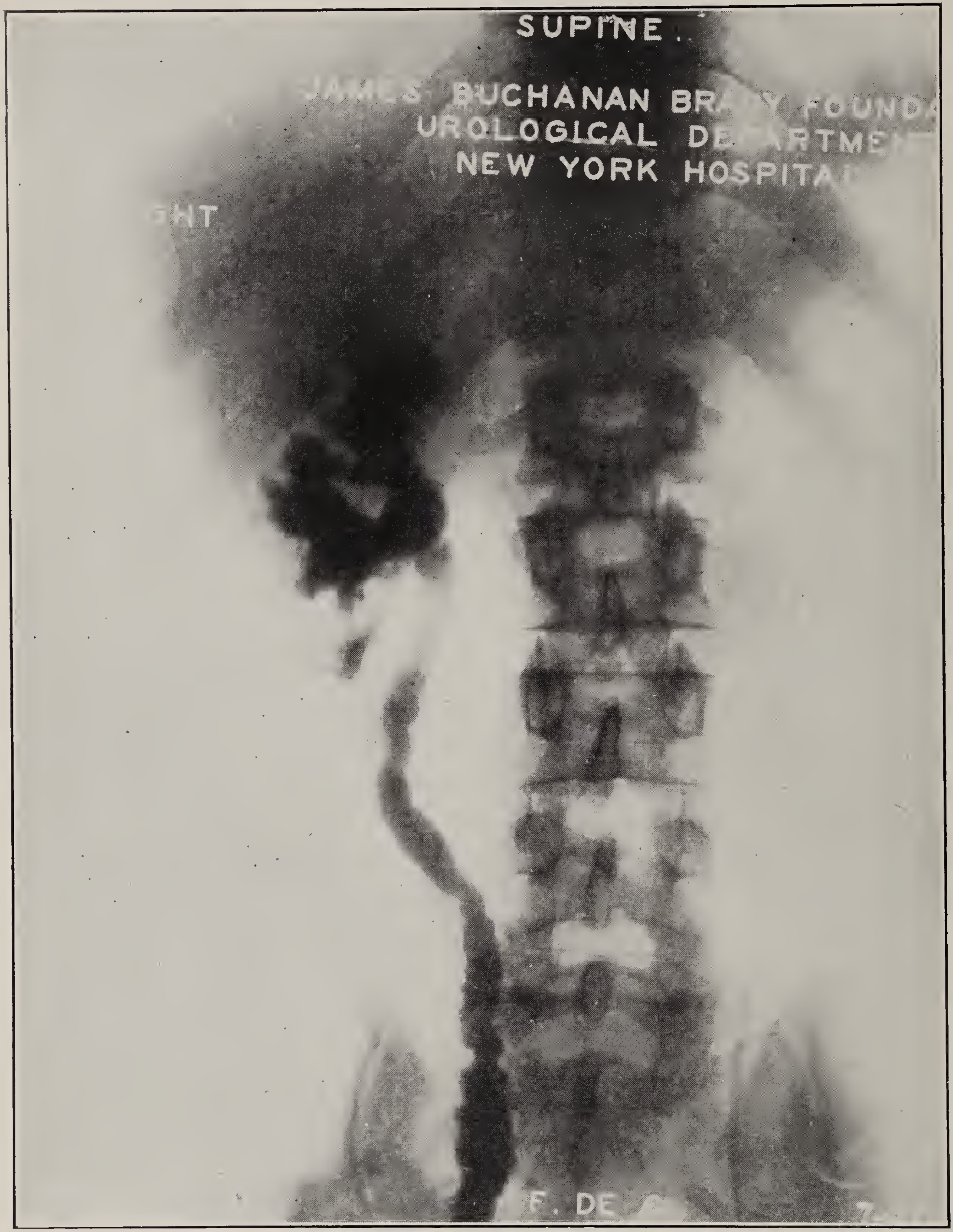

FIG. III. Value of ureterogram in diagnosis. Renal tuberculosis with ureteral involvement. The taking of ureterograms in all renal cases is a routine in the author's clinic.

X-ray tube may so distort the pyelo-ureterogram as to bring about an appearance of actual change in the structure of the kidney and ureter. With a standard degree of angulation such distortion should be rare, so this error is not likely to be made. Pressure exerted by the compression cone or the inflated bag may exaggerate the outline to a certain extent. Also displacement of the kidney may be apparent when the renal excursion is unusually wide, as in tumor of the kidney or renal ptosis. Compression should thus be avoided whenever possible, or allowance made for its effects.

Roentgenographic aspects of pyelitis. The normal calyx appears in the roentgenogram as a flower, the center being represented by the papillæ. If pyelitis be present the calyces will be distorted and smoothed away, this distortion being even more marked in such conditions as cystic kidney and tumor, and especially in pyonephrosis, a condition where the kidney is sometimes reduced to nothing more than a hollow shell filled with pus.

Hydronephrosis. The passage of the catheter will frequently produce the copious flow of urine which indicates that the obstruction which was causing a hydronephrosis has been surmounted, but far greater accuracy in diagnosis may be attained from the pyelogram, as this will show the size and exact location of the affected kidney, as well as the amount of renal damage it has caused. Frequently also, the ureteral obstruction or other causal factor will be revealed.

Calculus. The first diagnostic use of X-rays was the demonstration of renal stones, yet even with the improvements since introduced, the plain roentgenogram cannot be relied upon to reveal stones under all circumstances. But those which fail to cast a shadow when no opaque medium has been injected will invariably cause a thinning out of the pyelographic shadow. Even when the first exposure indicates that a stone is present, the additional pyelogram may still be necessary to determine its exact location and its relation to the pelvis. For example, as has been recently pointed out, if very small stones are impacted in the minor calyces, it is of the utmost importance to the operator to learn whether the affected calyx is anterior or posterior, whether the isthmus is of sufficient caliber to permit delivery of the stone into the true pelvis, and in addition whether the extra-renal portion of the pelvis is large enough to warrant the performance of a pyelotomy, should this maneuver prove to be desirable.

Tumors. One of the chief uses of pyelography is in the detection of neoplastic growths, and its employment makes the diagnosis of renal tumors possible far earlier than has heretofore been the case. If a patient

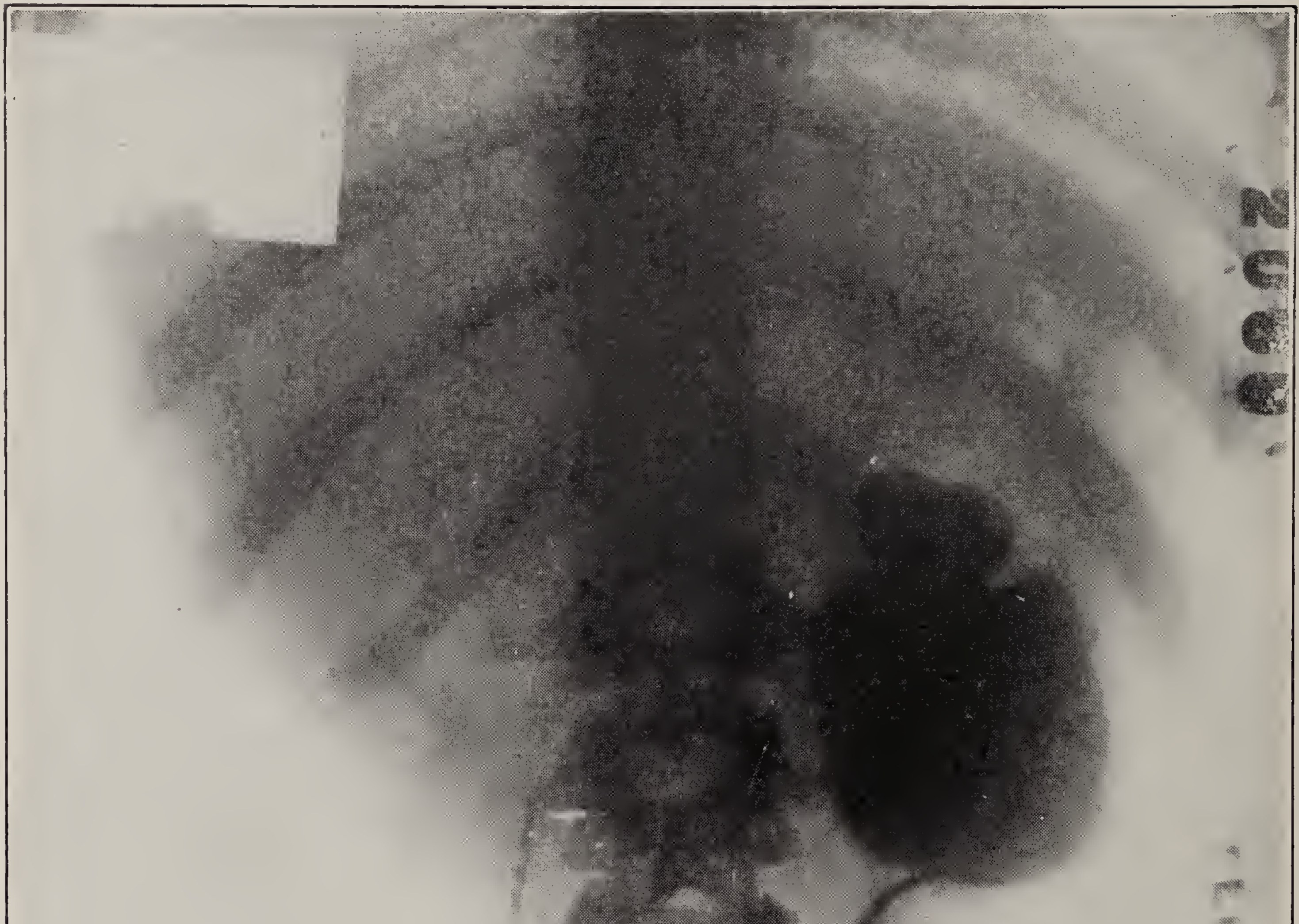

FIG. IV. Pyelogram showing pyonephrosis with kinked ureter.

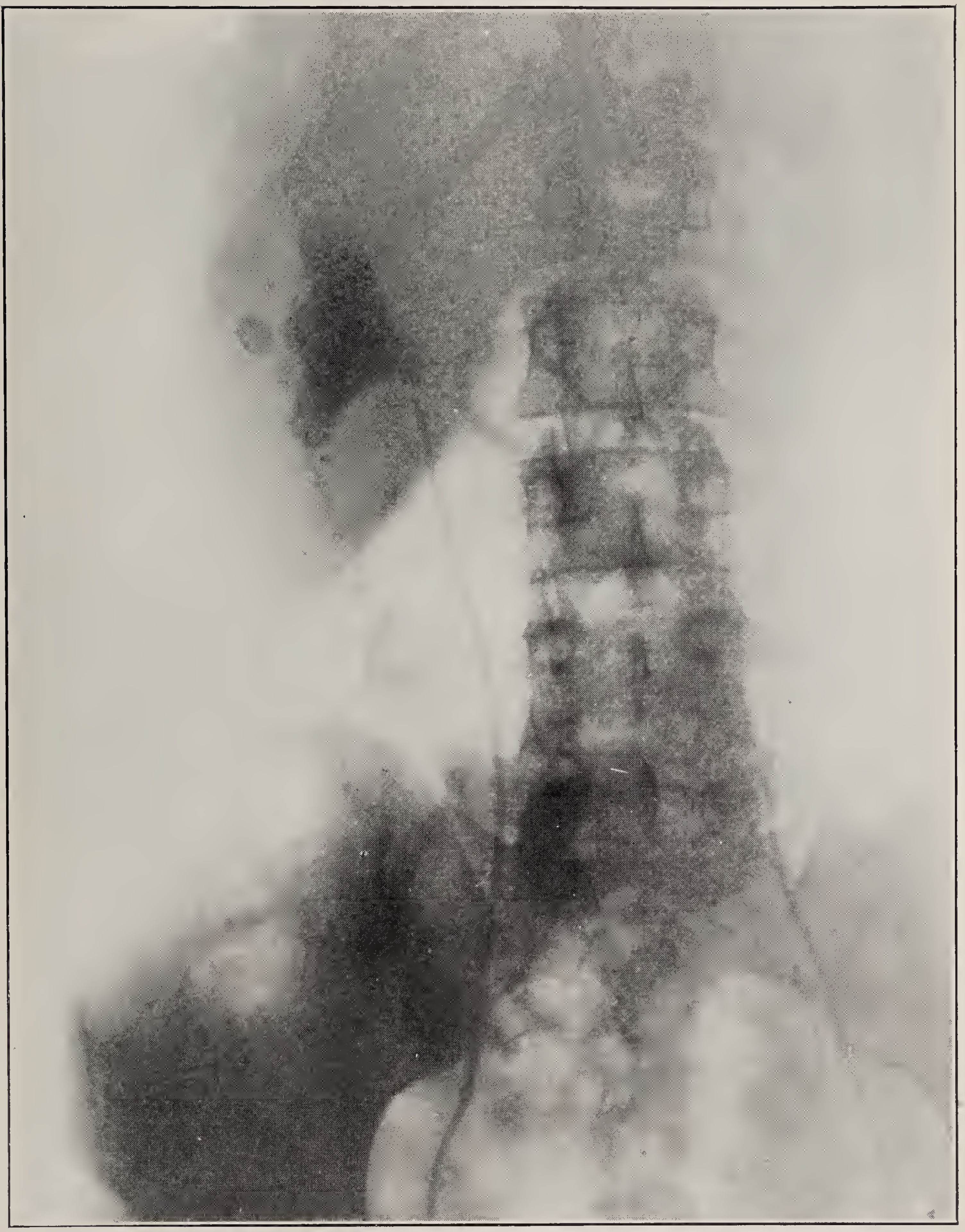

Fig. V. Single calculus occupying entire renal pelvis. Function markedly diminished before operation. The kidney was bisected and stone removed entire. Patient since cystoscoped yearly for five years; no return of stone; function much improved. Author's case.

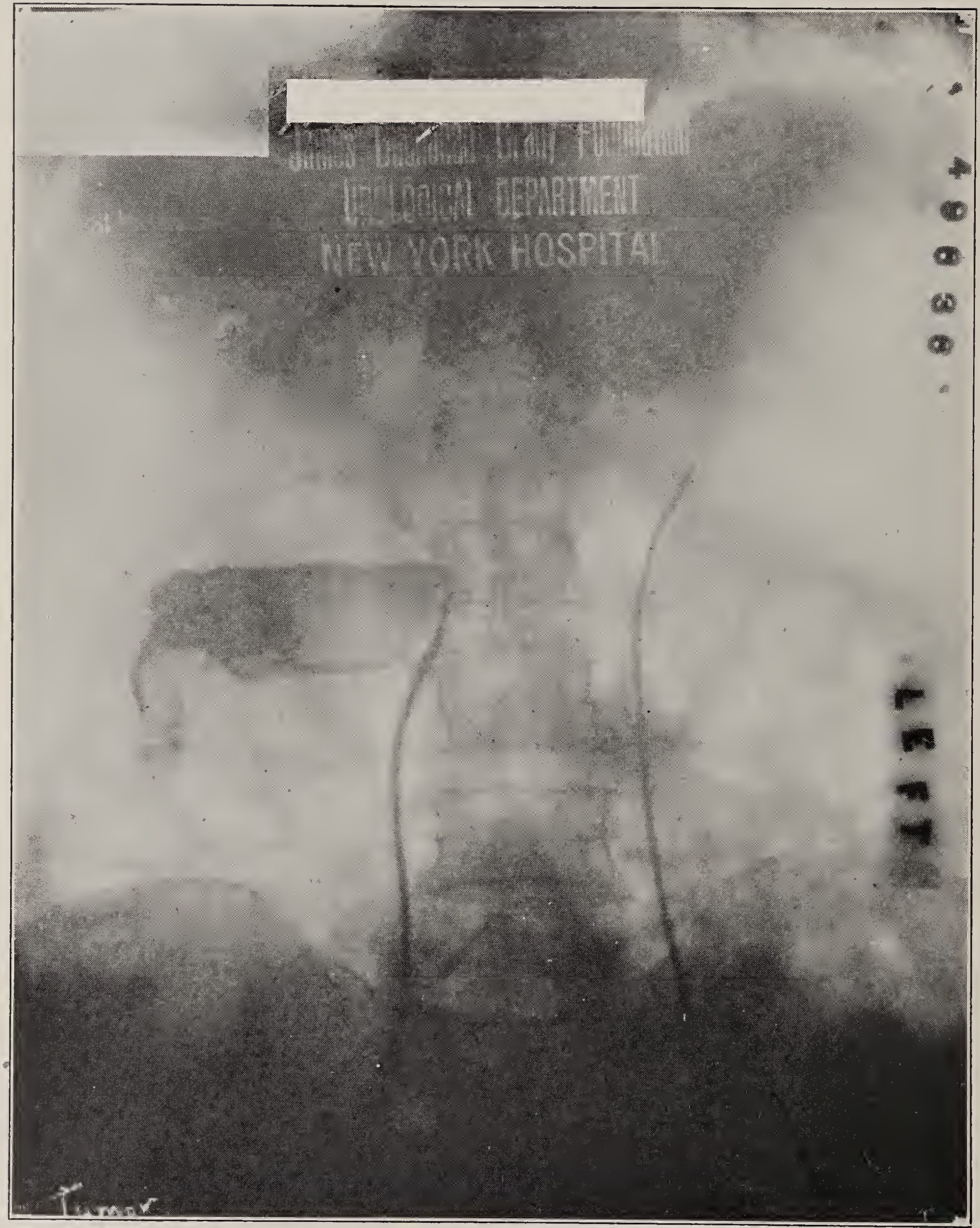

FIG. VI. Hypernephroma. Diagnosis made on pyelographic findings and confirmed by pathologic examination of removed specimen.

presents unilateral bleeding as established by separate catheterization, a pyelogram should always be made. A renal neoplasm always induces pressure on the pelvis very early in its existence so that distortion or so-called ‘ filling defect ’ in the pyelogram will at once indicate the presence of tumor.

Anomalies. The recent great extension of our knowledge of renal anomalies has been made possible only by the introduction of pyelography. In fact, before the discovery of the Roentgen rays, preoperative diagnosis of kidney anomalies was practically impossible. Even the cystoscopic discovery of absent or supernumerary ureteral orifices could do no more than suggest the probability of such malformations. At present, when ureter and pelvis are injected with an opaque medium the condition will usually be plainly indicated.

Renal tuberculosis. In the diagnosis of renal tuberculosis the X-ray examination is one of our chief aids. Often the plain roentgenogram will give such conclusive evidence that any further procedures are superfluous. In obscure cases stereoscopy has been found of great value. Those portions of the renal tissue occupied by calcium deposits, resulting from the activities of the tubercle bacilli, cast shadows with outlines so characteristic that the experienced observer needs nothing further. Confusion may sometimes arise with stone in the kidney but differential diagnosis is generally possible. Because the shadows cast by tuberculous calcification show a marked variation in density, being of irregular concentration in different parts of the negative, their shadows are on the whole much less concentrated than those caused by calculi. The outlines, too, are much hazier and less definite than those of stones, although many cases of stone produce such hazy and indistinct outlines that they are easily mistaken for those due to a tuberculous process. In general, the distinctive appearances of renal tuberculosis as indicated by roentgenographic shadows are: (1) Multiple and widely distributed areas of limited extent; (2) single, larger areas, or a smaller number of sharply defined and localized spots no less than one centimeter in diameter; (3) scattered, irregular areas of large size occupying a great extent of kidney surface, or practically replacing it. The first type of shadow is most often visible at the poles and is due to deposits of lime. The apparent size of the shadows of the second type must not be taken as an indication of the actual dimensions of the lesions they represent, for often they are cast by the areas of greatest density in a lesion which may occupy a much larger extent of tissue. The large shadows of the third type indicate a thin deposit of calcium which may be very extensive, but actually of less dimensions than those casting shadows of less extent. At times these are so faint that only

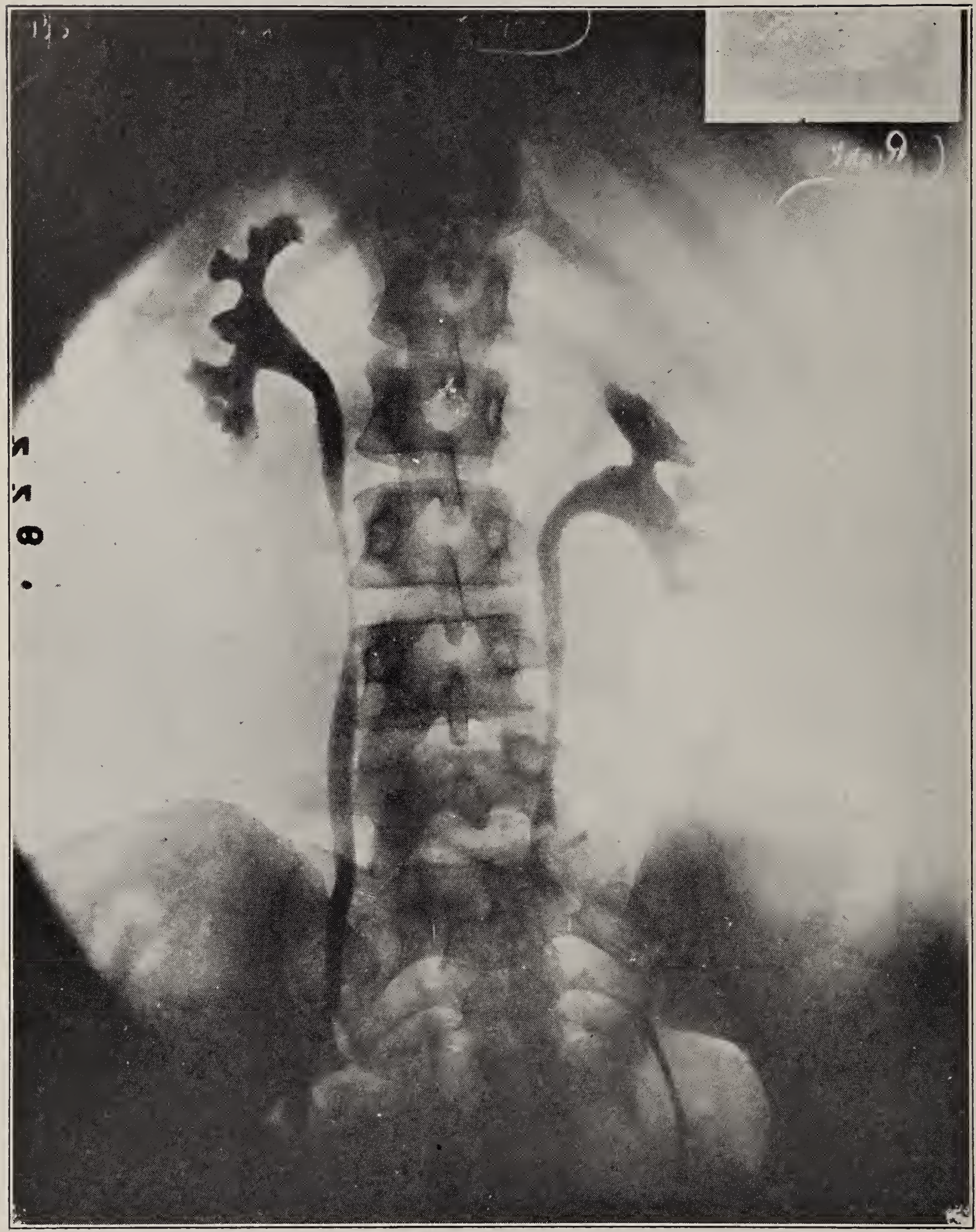

Fig. VII. Strictured ureter. Stricture remained constant in pyelograms taken at intervals of several days. Dilatation from 6 to 12 (French) relieved the patient of the urinary frequency for which she had been referred to the renal surgeon.

minute examination of the film will enable them to be detected. A kidney that has been entirely destroyed by a tuberculous process will cast such a definite and characteristic shadow that the experienced roentgenologist

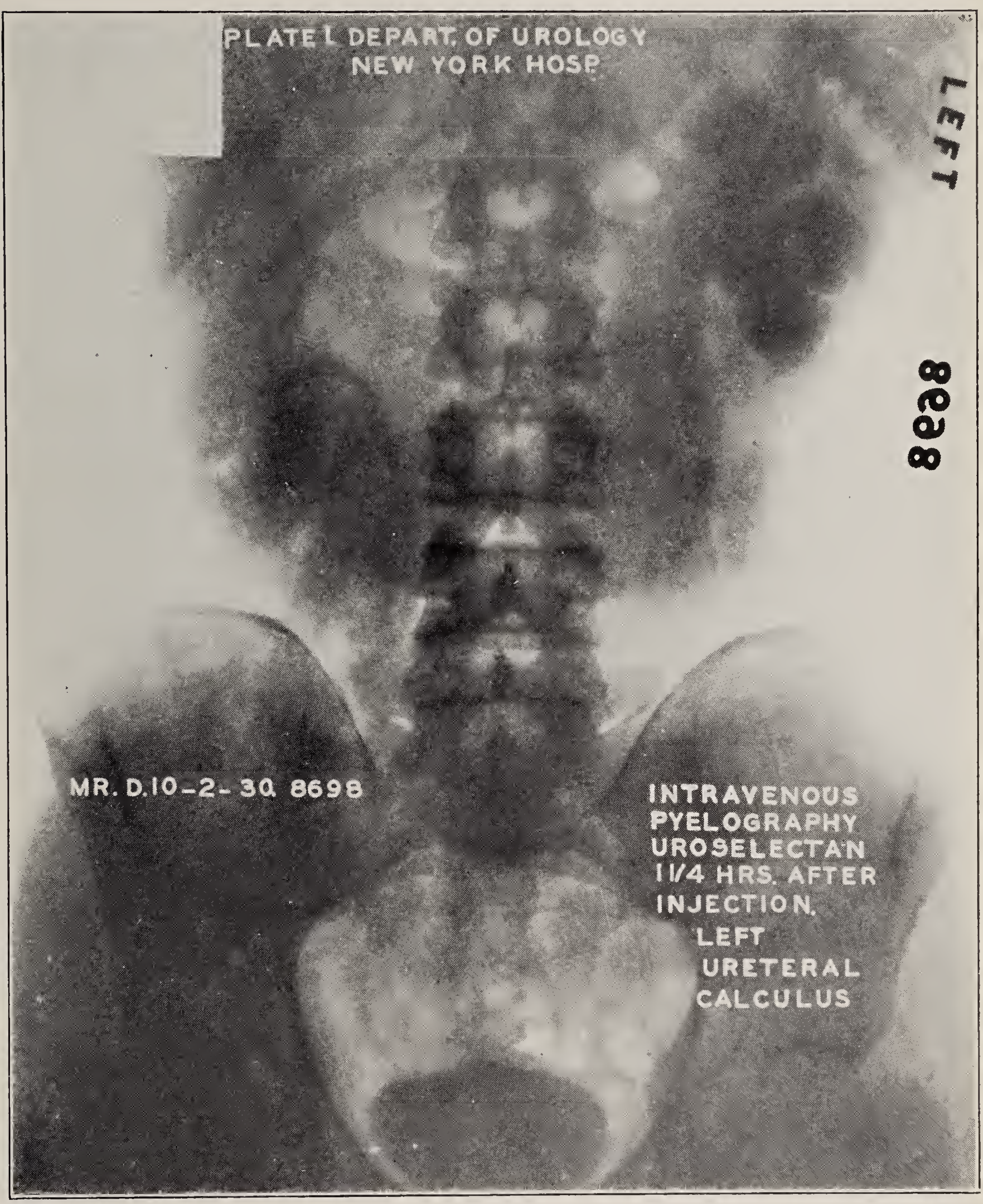

Fig. VIII. Intravenous Pyelography. Left ureteral calculus. Exposure made $1\frac{1}{4}$ hrs. after injection of Iopax (Uroselectan).

will need no confirmation, even if the tubercle bacilli are not found in the urine.

Contraindications. Marked impairment of function — expecially if bilateral — contraindicates pyelography. High temperature or other indications of renal infection, should also prohibit its use. Even slight distention of an inflamed surface will aggravate this condition, and any attempt at injection under such circumstances would be disastrous.

Iopax. There has now appeared a new method of visualization of the kidney and a limited part of the urinary tract by intravenous injection of the opaque medium, which gives every prospect of displacing, to a considerable degree at any rate, the present method of direct injection of the upper part of that tract. The contraindications just enumerated do not operate when this method is employed, so that it becomes much more widely applicable. Inasmuch as the procedure is very new, opinion must be reserved until we have wider clinical experience, but at present there seems to be little doubt that we have attained something almost as valuable as the original method — and a thousand-fold safer.

History. The success of Graham in making cholecystography practical encouraged urologic workers to hope that some similar procedure might be found for application to the urogenital tract. For a number of years past experiments toward this end have been carried out, but the final discovery was actually more or less accidental. Professor Binz and Dr. Raeth, working on the medical service of Professor Lichtwitz at the Staedtisches Krankenhaus, Hamburg-Altona (Germany), synthesized a compound designed for use against coccal infections, which received the name of Selectan-Neutral. This had an iodine content of 54 per cent. In the course of their studies the two experimenters observed expecially its excretion, and the fact of its high iodine content not unnaturally suggested that it might be useful for visualization with Roentgen rays. By making injections upon rabbits it was demonstrated that the kidney parenchyma and the urinary bladder became quite plainly outlined. This was not true of the renal pelvis nor of the ureter at first, but after ligation of the ureter, the upper part of the urinary tract made a better outline. When the urine was analyzed from 75 to 80 per cent. of the iodine injected was recovered. A few traces of it were detected in the bile, but the minutest examination of the rest of the animal's tissues failed to show that retention of the drug had taken place elsewhere. This practically complete elimination without deleterious effects offers strong proof of its availability as a visualizing medium suitable for intravenous injection. This hope was increased when attention was turned toward the aspects of toxicity and tolerance. When an amount not exceeding 0.2 grams per kilogram of body weight was intravenously administered to a rabbit there were no observable effects. When the amount injected was increased to 0.33 per kilogram of body weight there was considerable constitutional disturbance evident. Calculations based upon these data led to the con-

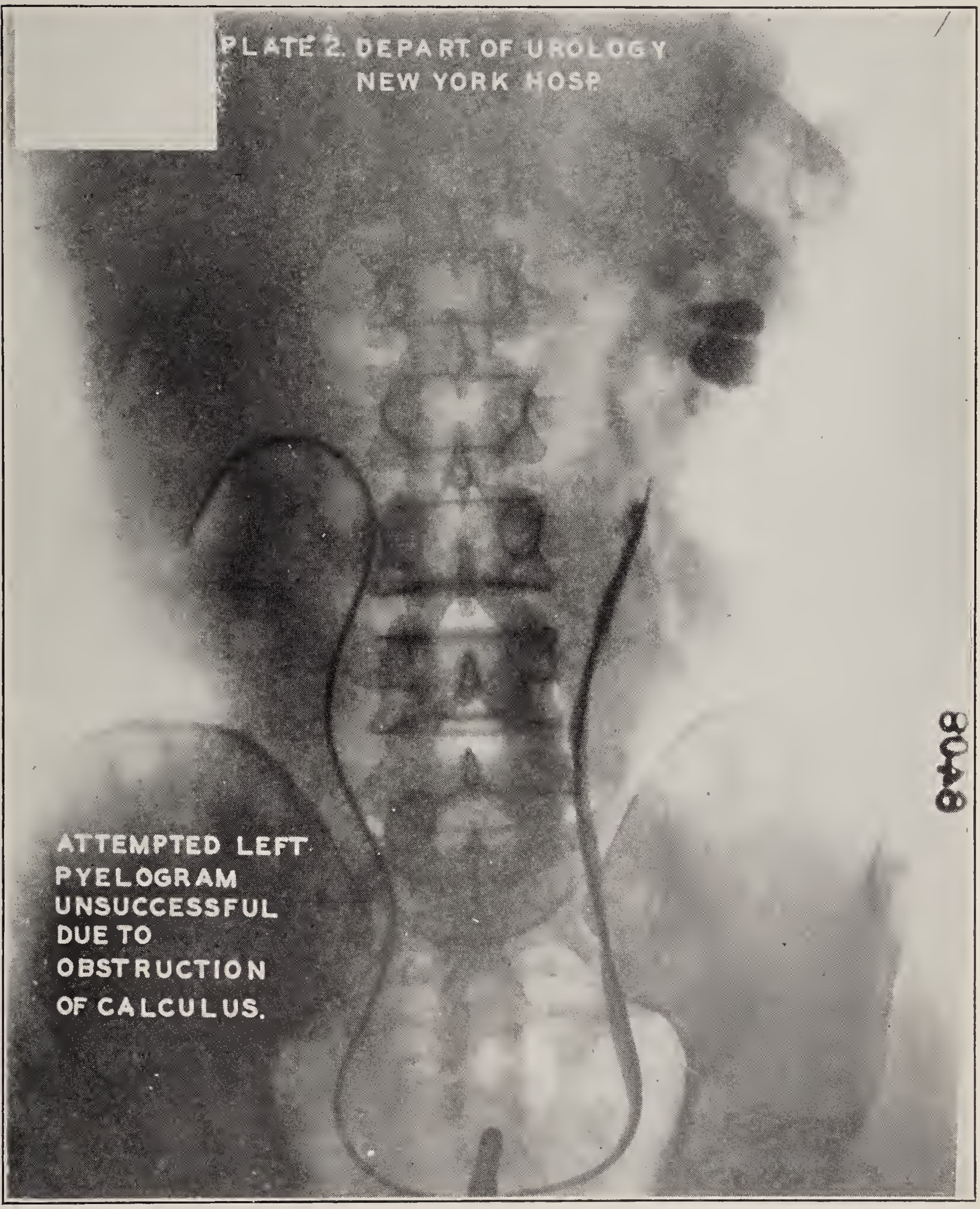
PLATE 2. DEPART. OF UROLOGY
NEW YORK HOSP.
ATTEMPTED LEFT PYELOGRAM UNSUCCESSFUL DUE TO OBSTRUCTION OF CALCULUS.
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Fig. IX. Injection of pyelographic medium; unsuccessful because of obstruction by calculus.

clusion that a dose as high as 18 grams might safely be given to a human being weighing 60 kilograms. Actual trial showed that human subjects varied considerably in their ability to withstand toxic effects. In some instances such phenomena as headache, nausea, vomiting, and occasionally transient diplopia gave warning of possible grave consequences. None of

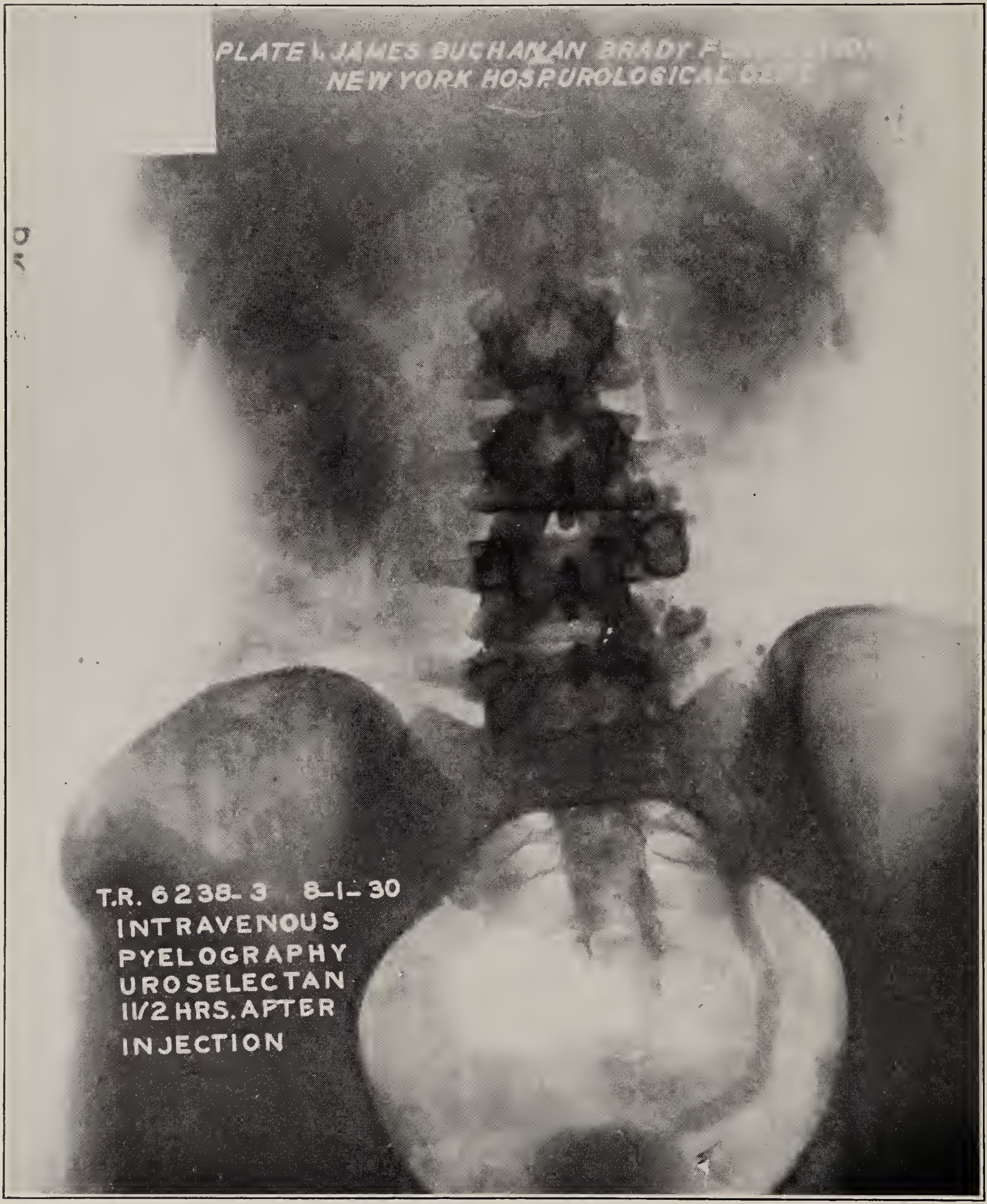


Fig. X. Intravenous pyelography; $1\frac{1}{2}$ hours after injection of Iopax (Uroselectan). Vol. 3. 331.

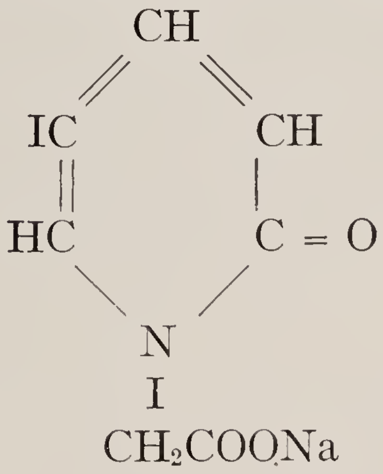
these reactions were, however, severe enough to cause the investigators to give up their endeavors. No great progress was made in producing clear outlines and it was soon seen that the compound under investigation would have to undergo some modifications before it would prove practical, at least for urologic work. The original intention had been the outlining of the gall-bladder. The films first made failed to show the gall-bladder but the outline of the kidney was surprisingly satisfactory, and this accidental finding changed the entire course of the investigation which was thereafter devoted to perfecting a medium for intravenous pyelography.

When Selectan-Neutral proved unsuitable, experiments toward perfecting the medium were undertaken, and among those who entered upon the work was Swick of New York at that time studying in Germany under the Emanuel Libman Fellowship. Swick has stated the problem which confronted him as follows:

(1) To diminish the toxicity of Selectan-Neutral through the substitution of the methyl group in order to permit the administration of a larger dose and thus attain a greater concentration of the excreted iodine component, a determining factor for roentgenologic success (the observation in the two diplopias suggested that the methyl radical might be responsible for the toxic effects). (2) To increase its solubility. (3) To increase the iodine content of the molecule. (4) To increase, if possible, the affinity for the kidney.

The scene of the activities of these experimenters was then transferred to the clinic of von Lichtenberg at the St. Hedwig's Krankenhaus, Berlin. Modification of Selectan-Neutral were prepared by its originators. The iodine content was reduced and substitution made for the methyl radical. Eventually a compound was produced which fulfilled the requirements sufficiently to be of practical clinical use. This was named *Uroselectan.* The Council of Pharmacy of the A. M. A. now designates it as *Iopax.*

Chemistry of Iopax. Sodium glycin was substituted for the methyl group, the iodine content was reduced, thereby increasing solubility, and the final formula resulting was the following:



Iopax is neutral, soluble in water to more than 50 per cent., and contains 42 per cent. of iodine. Its opacity to X-rays is about one-half that of 20 per cent. sodium iodide. It is an extremely stable chemical

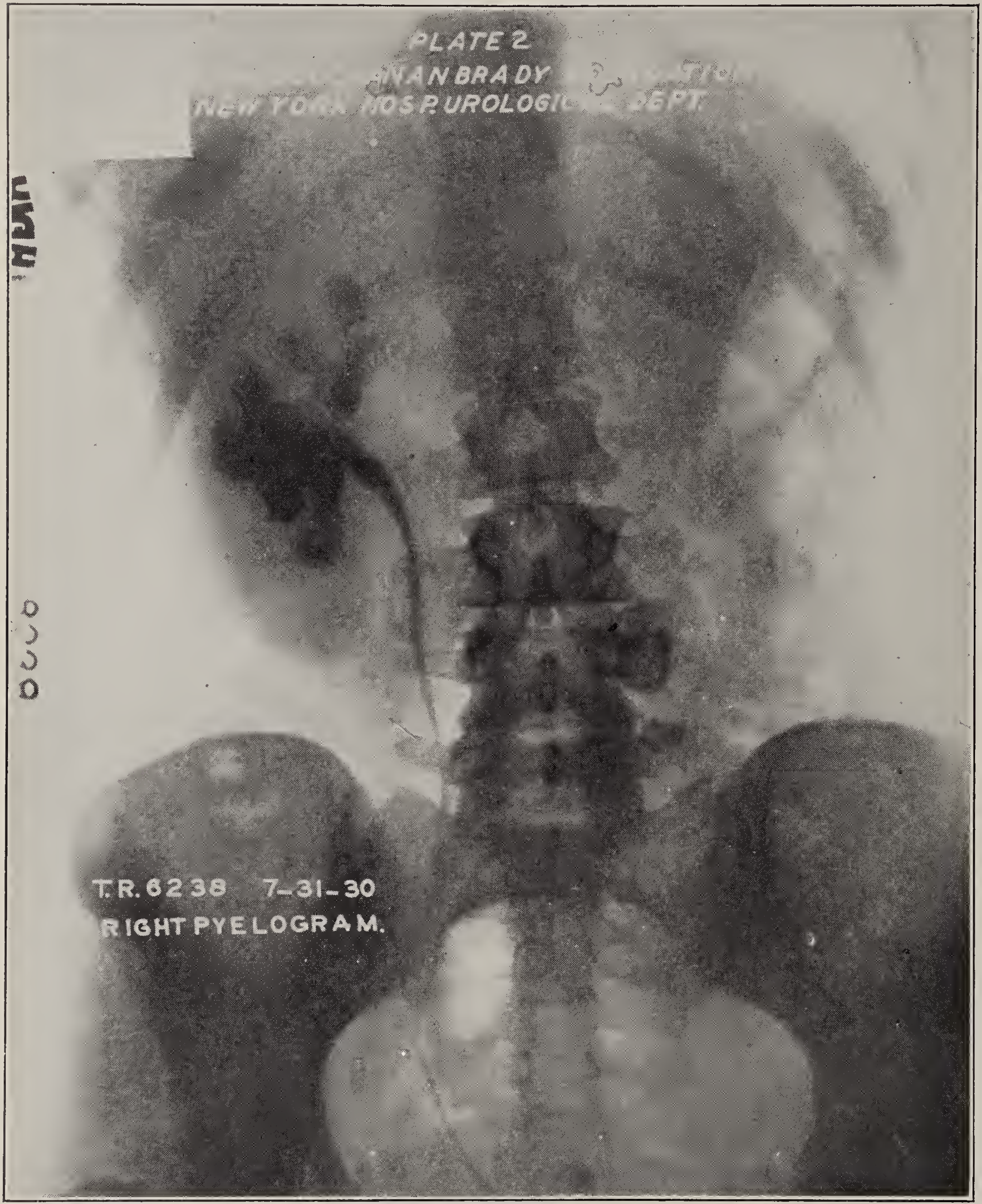


Fig. XI. Same case as Fig. X. Right pyelogram after injection of opaque medium.

compound, which can be introduced into the blood stream in relatively large amounts. If deductions from animal experiments are reliable it is possible to give an intravenous dose of 180 grams to a man weighing 50 kilos, but for clinical purposes 40 grams is all that is necessary to produce perfectly clear-cut shadows. This amount is dissolved in 80 ccm. of redistilled water, filtered twice and autoclaved for 20 minutes. The result is a heavy brown solution which, however, contains no free iodine. Experiments have been made with a view to sterilizing it by boiling. A solution used after three hours' boiling showed no toxic effects. For children the dose is proportionately smaller. The originators injected from 10 to 12 cm. of the 40 per cent. solution when the subject was under six years of age; from six to ten years they used 20 to 40 ccm.; while from ten to fifteen years the dose was 50 ccm.

Technique. The usual preparation for the taking of roentgenoscopic pictures is carried out, and the patient subjected to a preliminary exposure for a ' plain ' roentgenogram. The injection is then made very slowly into a vein, the temperature being kept just at body heat. It is better to give two doses, equal in amount, and permit an interval of two or three minutes to elapse between them. Thereafter radiograms are taken beginning fifteen minutes after the first injection. The second radiogram is taken three-quarters of an hour afterward, and the third one and one-quarter hours after injection.

Speaking generally, the rate of excretion bears a direct relationship to the renal function as determined by the older tests. In cases where renal function is good, not only will the whole urinary tract be visible, but there will often be a definite increase in the normal renal shadow. The standard of radiographic technique demanded is high. The shadow thrown by the drug as it is excreted by the kidney is not quite as dense as that ordinarily obtained by the introduction of media through ureteric catheters, and so it is of the most supreme importance to obtain a maximum of contrast upon the radiogram. It has been advised to use a low penetrating ray, such as emitted from a tube excited by a maximum potential of 65 kilovolts peak.

A Potter-Bucky diaphragm fitted with a pressure band, and used in conjunction with double intensifying screen, has been advised. The focal distance should be thirty inches. With a milliamperage of 60, the exposure will vary with the bulk and build of the patient; perhaps 1 to 5 seconds is a fair average. The resulting radiograms should be developed for five minutes in a standard developer heated to exactly 65 degrees. When completed they should be examined in lanterns of equal luminant power. No variation from the normal procedure should be permitted. Films 15 × 12 will be found of a convenient size. Vol. 3. 331.

It is well to seek for an iodide idiosyncrasy before giving Iopax, which is easily accomplished by the administration of potassium iodide. The solution can best be administered by injection into the median basilic vein, and but a single puncture should be made.

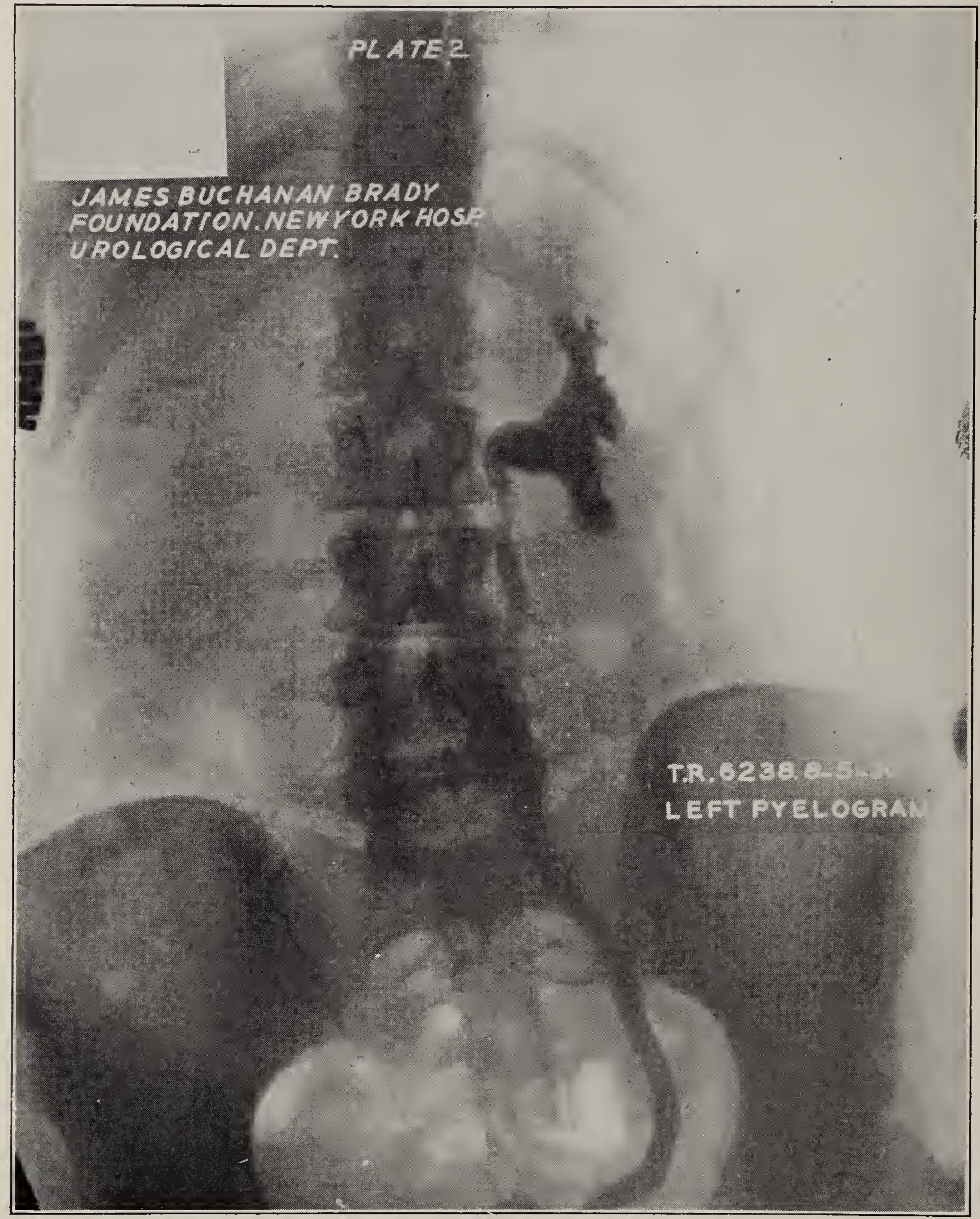


Fig. XII. Left pyelogram of same case as Fig. XI.

Following the technique outlined one should obtain a good view of the entire urinary tract. Comparison of the two kidneys is possible at every sitting, and this alone will be found so advantageous as to add greatly to the value of the method. If exposures are made 30, 60 and 120 minutes

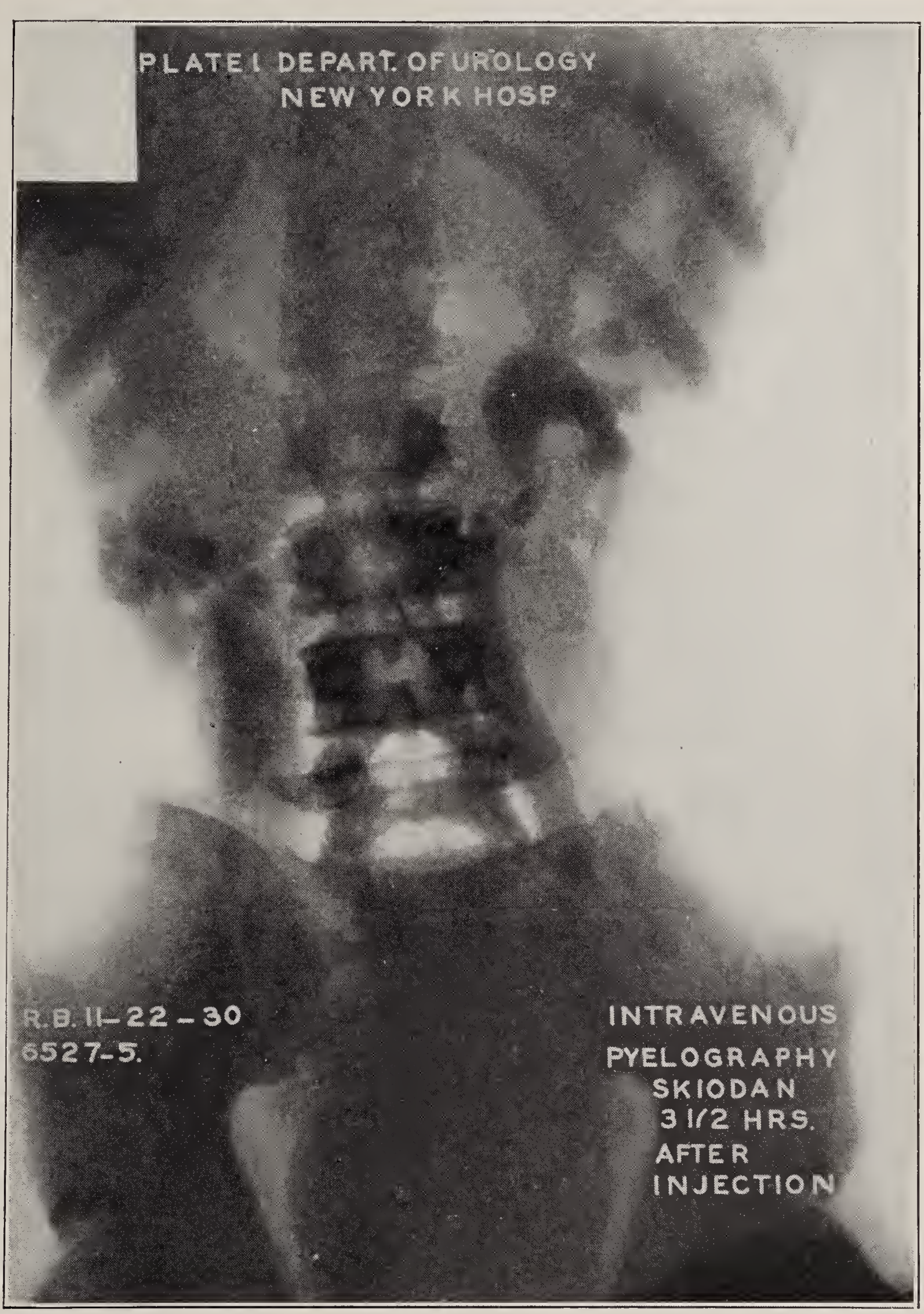


Fig. XIII. Intravenous pyelography with Skiodan*; 3½ hrs. after injection.

after injection, the bladder should be emptied just before the second and third films are made. If this precaution is not observed so much of the drug will have concentrated in the bladder that its shadow will obscure the lower part of the ureter.

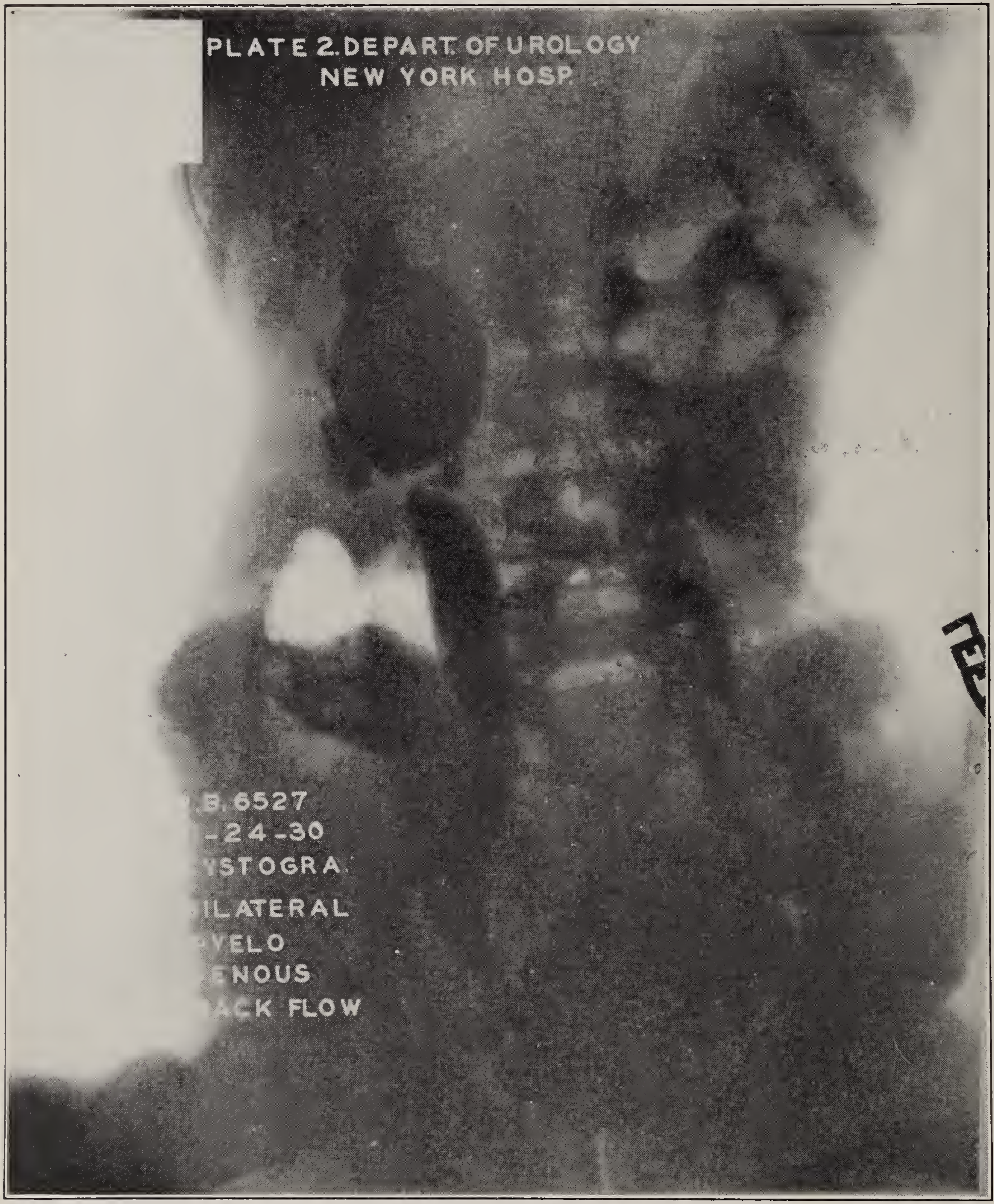


Fig. XIV. Same case as Fig. XIII. Injection of opaque medium. Bilateral pyelovenous backflow.

If the renal function is normal a shadow of the whole excretory portion of the urinary tract may be obtained within a half hour of injection, and this will be visible for several hours. If function is less than normal there will be a corresponding loss in the density of the shadow when compared with the opposite side. There will also be delayed appearance. When renal impairment is very severe the shadow may not be seen for from six to twenty-four hours — indeed we may never see it at all. If no kidney shadow is to be seen, it *may* mean that the organ is actually missing. Much more probable is it, however, that the kidney is inactive or severely damaged by some such condition as pyonephrosis, tuberculosis or tumor. In the first communication which he made concerning Uroselectan, von Lichtenberg said that though advanced hydronephrosis may eventually be expected to cast a fairly dense shadow — even though its appearance be somewhat delayed — pyonephrosis or infected and congested kidneys will often cast no shadows whatsoever, no matter how long they are waited for. It is evident that where poor function of one or both kidneys is suspected, the method must be used with the greatest discretion and should never be employed before a complete clinical examination of the urinary tract has been carried out.

At the Berlin clinic the drug has been given an extensive trial by von Lichtenberg and Swick. The indications which their present experience has established are to be summed up as:

(1) When cystoscopy and ureteral catheterization are especially difficult, either because of pain or the presence of a condition such as renal tuberculosis, when the use of catheters may be disastrous. Even the very slight trauma of passing an instrument through a tuberculous ureter is a grave hazard. The presence of urethral stricture, hypertrophy of the prostate, of excessive hemorrhage or intractable cystitis, might likewise forbid ureteral catheterization.

(2) For cases where it is known or suspected that the ureter on one side only is obstructed. The existence of a ureteral obstruction holds the drug in much higher concentration in the renal pelvis, thus casting a darker shadow.

(3) In cases where ureteral transplantation has been done, rendering passage of catheters impossible.

(4) In children and in patients of any age who are unable to co-operate with the examiner, or to whom routine pyelography would be too shock-producing.

Reaction of patients to injection. The injections so far given to man — now numbering tens of thousands — have been followed by no ill effects in all but a very few instances, and even with these there was no certainty that the untoward accidents could be in any way attributed to the pyelographic medium used. Within a few minutes after the injection is made the patient's pulse rate is increased by 10 or 15 beats per minute, and blood pressure raised 10 to 12 mg. of mercury. These both return

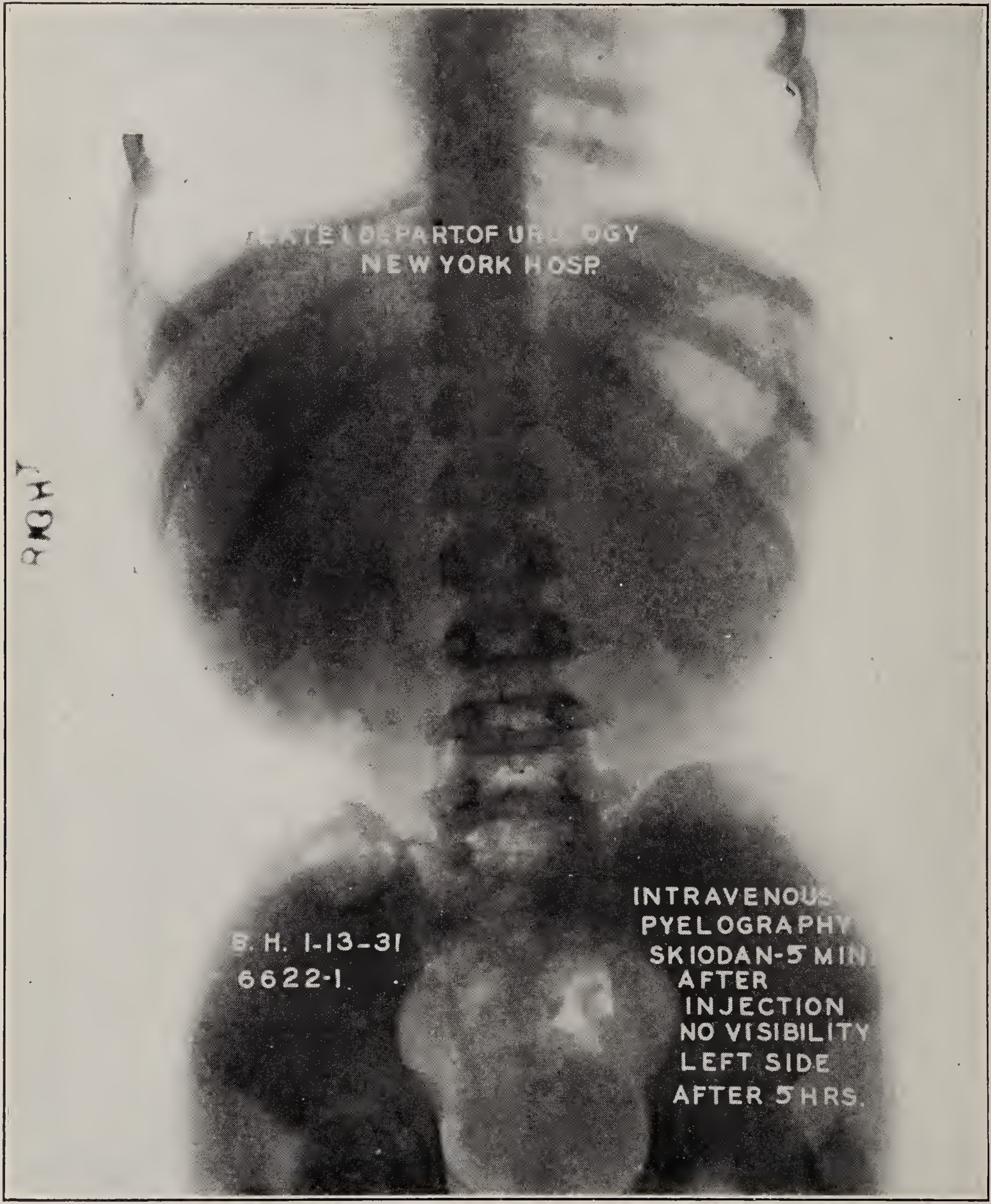


FIG. XV. Intravenous pyelography. Five minutes after injection of Skiodan. (There was no visibility on the left side after 5 hours.)

to normal within fifteen minutes and remain so thereafter. During this brief period of heightened blood pressure some of the patients have complained of slight dizziness; occasionally there is a transient cramp in the anterior shoulder muscles, but this is in no way distressing. One user has reported that a patient who was very nervous and complained of giddiness was able, immediately after injection, to stand up for fluoroscopic screen examination. When small quantities of the drug have been accidentally injected outside a vein there has been no untoward result. It has already been mentioned that urine passed and examined only a short time after concentration of the drug in the bladder is first visible will show no free iodine, and that iodine disappears from both blood and urine within a quarter of an hour. Experience has shown that the drug can be given with perfect safety, even in cases where there is such a marked decrease of renal function that the dye has been retained in the circulation from 24 to 30 hours.

Iopax is recovered very readily from the urine. On the addition of hydrochloric acid it forms a heavy white precipitate when the *p*H reaches 2.8 to 3. This makes it available as a very excellent renal function test. Yet as the specific gravity is a very reliable guide to the amount of the drug present, it is often unnecessary to go to the trouble of careful chemical estimation. Specific gravity should attain 1045 to 1050 within one hour's time, as this is about the length of the period during which the drug is excreted. It is probably not so reliable a test of renal function as those already in use, but it has not been available long enough as yet to prove or disprove this point. It would seem that the presence of infection is more likely to act to retard its excretion than is the case when indigo-carmine is used. It has been stated by von Lichtenberg, and the English experimenters Roth and Wright have confirmed this, that while an advanced non-infected hydronephrosis will give an excellent though perhaps a delayed shadow, a pyonephrotic and infected — or possibly congested — kidney will give no shadow at all. But in 70 per cent. of von Lichtenberg's 84 cases the necessity for cystoscopy was eliminated, which — to the patient at least — was undoubtedly a great advantage.

The applications of Iopax are still restricted, as must be the case with every new thing until it has received wide clinical trial. It seems probable that further study and experiment will extend the scope of its usefulness. Should it prove beyond question to be as innocuous as its originators claim, it will undoubtedly supplant the present system of pyelography by direct injection to a very large extent. As to prove practically useful in diagnosis great skill in interpreting the X-ray films is absolutely essential, the method will be always confined to those who are particularly expert, both in roentgenographic diagnosis and urinary tract pathology. But undoubtedly it will be employed by many who in no wise fulfil either of these requirements, and for this reason may fall into undeserved disrepute before its real value is rightly appreciated.

Pneumoperitoneum. Another development of X-ray technique in relation to renal diagnosis is the method known as pneumoperitoneum, which consists of inflating the abdominal cavity by air or gas and observing the patient before the fluoroscopic screen. This procedure usually causes the patient considerable pain in the shoulders so that it is by no means free from suffering. It need hardly be added that only one skilled in surgical technique and thoroughly conversant with the anatomy and pathology of the abdominal region should ever attempt to apply it.

The advantages of pneumoperitoneum in renal diagnosis are so great that its employment is warranted when other less drastic means have failed. The existence or absence of a second kidney can sometimes be demonstrated in no other way, and tuberculosis and renal cyst have also been discovered after all other resources had been exhausted. Used in conjunction with pyelography, it makes possible a clear outlining, not only of the ureters and kidney pelves but of the renal organs themselves. Thus any deformities or enlargements are visible as by no other technique.

SURGICAL CONDITIONS OF THE KIDNEY

Infections of the kidney. Until very recently renal infections were regarded as subject only to medical treatment. Their consideration would have had no place in a discussion of renal surgery. But with extended study of all lesions of the urinary tract it has been gradually realized that many kidney infections are secondary to so-called ‘ surgical ’ conditions, and that the only rational treatment for them is to remove the primary cause. Inevitably then, at least a brief discussion of this class of renal lesions is appropriate, and an understanding of the etiology and pathology of such conditions essential to complete diagnostic comprehension on the surgeon’s part. Moreover, so many infectious organisms are capable of producing conditions which surgery alone can relieve, that at present their operative treatment has become a commonplace occurrence.

Abscess formation. The colon bacillus is the organism most frequently infecting the kidney. But as its tendency is to produce widespread inflammation without abscess formation the surgeon is seldom called in when this infective agent alone is present. Pyogenic cocci — *Staphylococcus*, *Streptococcus*, etc. — are productive of multiple abscess formation in the renal tissue, at times converting the entire organ into a mere pus-filled shell. Marked tenderness at the costo-vertebral angle is often the only symptom elicited which offers any differentiation from such abdominal conditions as inflammation of the gall-bladder, liver, or appen-

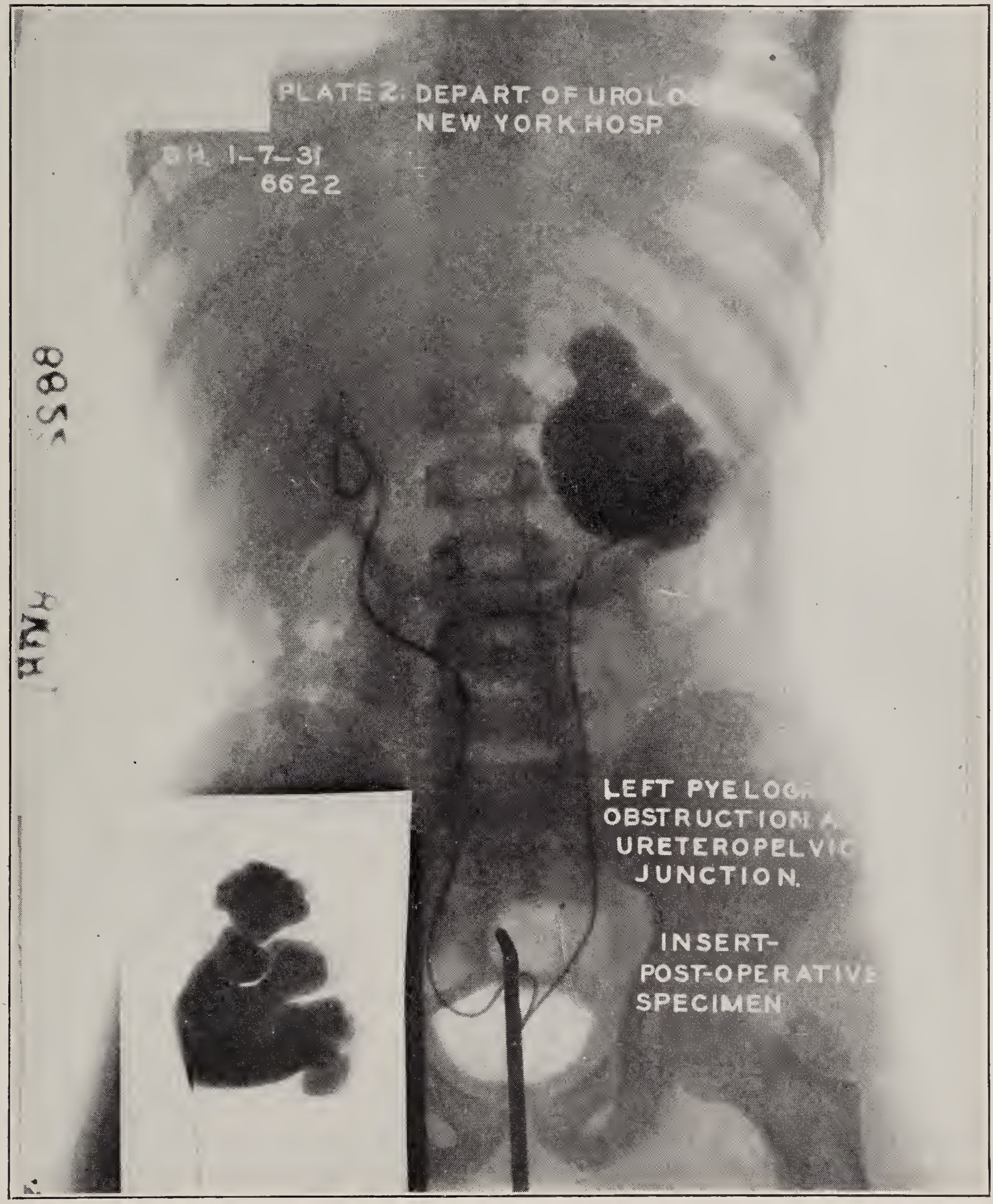


Fig. XVI. Left pyelogram after injection of opaque medium, showing obstruction at the ureteropelvic junction. The post-operative specimen is shown in the insert.

dix, or even an acute digestive disturbance. While pus will appear in the urine, this is not distinctive enough to give much aid in diagnosis.

When we employ the term *pyelitis* reference is made to an abscess condition which is confined to the kidney pelvis alone. *Pyonephrosis* designates the dissemination of multiple abscesses through the cortex of the medullary portion. Multiple cortical abscesses show on the surface only as minute yellowish spots. When an extirpated organ is sectioned these will be observed to extend for some distance into the kidney tissue. Again, the abscess formation may be much more extensive, forming *carbuncle of the kidney*. This is often accompanied by thrombosis of the entire blood supply of the affected organ, with rapid necrosis.

Treatment. If renal abscesses are correctly diagnosed and explored in their early stages it may be possible to institute drainage and eventually restore the kidney to fairly good functional condition. Unfortunately, it is seldom that nephrotomy is undertaken while it is still efficient. In the majority of cases nephrectomy alone will save the patient's life.

Pyelonephrosis. This form of renal suppuration is due to dilatation of the calyces and pelvis of the kidney with pus, distension often being increased by the retention of urine. The process of suppuration and the dilatation of the calyces may have taken place at the same time, tissues already subject to a uronephrosis being invaded. Ulceration in the ureter, or trauma such as is caused by the presence of stone, or a process which casts off much detritus — as tuberculosis — are any of them sufficient to set up a pyonephrosis as soon as infection can gain an entrance. The course of pyelonephrosis is more protracted than that pursued by pyelonephritis. An aid to differential diagnosis is the fact that a tumor mass is invariably present in pyelonephrosis. This may vary considerably in size, not only in different patients but at different times in the same patient.

Evacuation of the infected collection is indicated as early as possible. This is best accomplished by a lumbar incision through which free drainage may be instituted. Some surgeons split the entire organ. Primary nephrectomy is indicated in pyelonephrosis if a careful preliminary examination has shown that the unaffected kidney can do the work of both sides and the extent and location of the suppurative process makes proper drainage impossible. If perinephritic suppuration is also discovered, the kidney may act as a valve to impede drainage, abolishing any chance of the organ ever being functionally useful again.

Actinomycosis of the kidney. This is a very rare condition and one which manifests itself by symptoms like those of renal tuberculosis, the resemblance being so close that the diagnosis is seldom made during life. In a case reported by Kellock of the Middlesex Hospital, London, in 1905, the diagnosis of tuberculosis was made and the kidney removed. It was only upon microscopical examination of the pus found in a suppurating cavity that any suspicion of error was entertained. In this pus appeared small granules which proved to be masses of a streptothrix parasite. The author remarks that the only point which might previously have cast a doubt upon the correctness of the diagnosis was the comparative ease with which a kidney of this size was separated from the surrounding structures. " One would have expected to find a tuberculous kidney measuring 7½ inches in length to have been very much more adherent."

Renal infection with this fungus is almost always secondary to processes elsewhere in the body and may well be wholly overlooked, except in the presence of the characteristic pus which chances to be detected in the urine. In a few cases a sinus has formed from the affected kidney to the exterior of the body, and in the discharge from this the typical granules have appeared and determined the causal factor.

Treatment. The treatment will vary according to the related conditions present. In general, the measures useful in renal tuberculosis are applicable, and when nephrectomy can be done, it will undoubtedly be likely to produce the best results.

RENAL TUBERCULOSIS

Tuberculosis of the kidney is becoming more and more a " surgical disease." The good results which have followed removal of diseased renal organs emphasize the possibilities which this line of treatment holds out. Primary tuberculosis of the kidney is a comparatively rare lesion, yet it occurs frequently enough to make it advisable for every examiner to be on his guard, and to apply all the available tests before ruling it out when the symptoms are at all characteristic.

Hematuria and cystitis are the first complaints in fully nine-tenths of the cases. As many of its manifestations are similar to those of renal tumor — especially the malignant growths — the age of the patient has an important bearing. Cancer of the kidney or bladder seldom appears before the fortieth year of age. The years between twenty and thirty-five are those when renal tuberculosis is most in evidence. Cystoscopic inspection of the bladder will often provide all the data needed beyond the demonstration of tubercle bacilli in the urine. Catheterization of both ureters and functional tests are, of course, necessary before nephrectomy can be undertaken. Pyelography is essential in many patients if a positive diagnosis is to be reached, and animal inoculation, which is now a routine in most clinics, will serve to confirm the findings reached by other means.

“ Closed ” renal tuberculosis is an extremely difficult lesion to establish, as many or all of the characteristic manifestations will be absent. If the tubercular process early causes a stricture of the ureter the organisms will never invade the bladder to any extent. Once the ureter is completely occluded, the dangers of cystitis are removed and there will be no tubercle bacilli demonstrable in the urine. Neither will there be hematuria, nor ulceration about the ureteral meatus. The plain roentgenogram may show practically complete calcification and attempts to pass a catheter will be halted by the stricture. Without the aid of X-rays the surgeon would be able to obtain little or no information as to the state of the suspected kidney.

The most common form of tubercular involvement is a slow infiltration of the parenchyma by numerous small infective foci, these later degenerating into circumscribed tubercles which eventually undergo caseous degeneration. This process seldom attacks both kidneys at the outset, and its evolution is usually slow. For these reasons early detection and prompt removal of the infected organ hold out good hope of cure. Unfortunately, the onset is so insiduous, and examination by a competent physician frequently so long delayed that when many cases are seen for the first time it is already too late to offer much hope of cure. Physicians should make every endeavor to impress upon the laity the prevalence of renal tuberculosis and preach the gospel that irritable bladder and hematuria in young adults, especially males, should always be regarded with suspicion and be subjected to prompt and thorough investigation. A more general knowledge of these facts would undoubtedly save many lives which are now needlessly sacrificed.

There is still considerable question as to the wisdom of using surgical measures, even in those cases where they seem peculiarly applicable. Many factors must also be taken into consideration which have no direct bearing upon the suitability of the case for surgery. When the patient is financially able to devote himself exclusively to “ taking the cure ” which has become established in the treatment of pulmonary tuberculosis, it may be wiser to confine his treatment to general hygienic measures and omit surgical intervention. Whereas another patient in a very similar physical state may be anxious to incur the risks attending operation in preference to a long period of inactivity from which no greater promise of permanent cure is offered. Each case therefore, must be decided on its individual merits and only those subjected to surgery whom the opinion of those in a

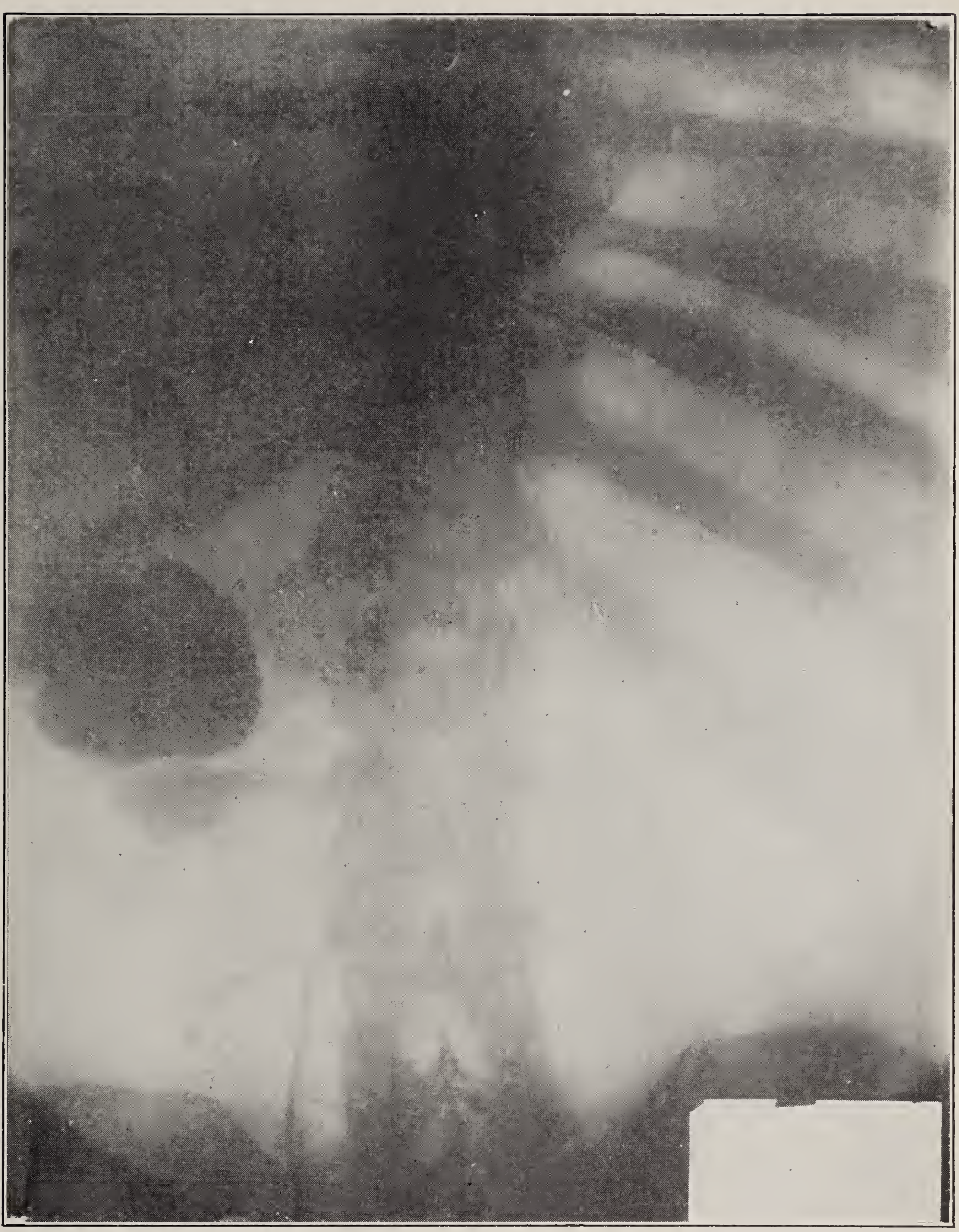


FIG. XVII. Perinephritis abscess, diagnosed as pyonephrosis. On operation the abscess was found confined to the capsule, but communicating with the renal pelvis by a small fistula. Through this opening the pyelographic medium had passed into the abscess cavity, the resulting pyelogram giving the appearance of a pyonephrotic kidney.

position to judge, considers the most suitable for this particular form of treatment.

It is the present author's personal opinion that surgical extirpation offers the only hope of cure that we are justified in entertaining. The position occupied by Young seems to him the only logical one. Early diagnosis and prompt removal of all the diseased portions of the urogenital tract, though counted as highly radical, actually shows a higher percentage of cures than has been obtained by any other means. The procedure, as outlined and practiced by Young, is a triumph of urologic surgery. Sufficient time has not yet elapsed since it was put to general use to permit generalizing from long-standing records of complete freedom from the disease. Yet what data we have point to continually extended usefulness for this procedure.

Perinephritic abscess. Perinephritic suppuration results from an extension into the perirenal fat of a pyelitis or other infectious process within the kidney. When the condition is intra-renal it is usually secondary to calculus formation, or some infection such as tuberculosis. It may occasionally be dependent upon a focal infection elsewhere in the body. The symptoms of such an abscess are similar to those of abscess elsewhere. The pain is frequently referred to the hip because of the irritation or actual involvement of the psoas muscle. The most common location is behind the kidney with extension toward the lower pole. If the pus collects behind the upper pole, the symptoms may simulate those of subphrenic abscess, as diaphragmatic extension will be limited. Wherever situated, the most marked symptom will be local swelling. This should not be confused with enlargement of the kidney itself as it is always diffused and shows no sharply outlined limits of excursion. It is quite uninfluenced by respiration.

Surgical treatment. Surgical intervention is indicated as soon as fluctuation gives positive evidence of pus collection. If left untreated, the pus may burrow down toward the groin or upward in the direction of the diaphragm, and whenever it finally finds an exit, a discharging fistula is likely to remain for a long time, provided the case does not progress to peritonitis and a rapidly fatal termination.

Hydronephrosis. Retention of urine may take place in either kidney or ureter when obstruction is present. This will result in dilatation of calyces and pelvis and — if long-continued — in atrophy of the renal cortex. When this retained fluid remains sterile we have hydronephrosis. This may involve the entire organ, or be localized to a single calyx, depending upon the nature and position of the obstruction to drainage. It is at once evident that we may have as many varieties of hydronephrosis as there are possible ways of obstruction to the normal outflow of urine.

Hydronephrosis may be either congenital or acquired. The second form is undoubtedly of far more frequent occurrence. In the majority of cases the first manifestations take place between twenty and thirty-five years of age. Anomalous kidneys are peculiarly subject to retention, but precisely why this is so we have not, as yet, discovered. A short time ago E. Papin, the distinguished French urologist, published in the journal of which he is editor — *Archives des maladies des reins* — a very interesting account of four cases of polycystic kidney all of which were complicated by the presence of hydronephrosis. The first of these was clearly congenital, there being hydroureter as well as hydronephrosis and a stricture of the duct in addition to the polycystic condition of the kidney. All were clearly demonstrated by pyelography. The patient was fifty-three years of age, but until he was past forty had enjoyed good health without any urinary symptoms. One testicle was undescended — on the same side as the polycystic kidney — the right. Function of the left kidney was excellent and that half of the genito-urinary tract apparently normal. Right nephrectomy relieved the patient of all his symptoms and three years later he was in good health and actively engaged in his trade of locksmith. This case is especially interesting in view of the universally accepted opinion that surgery is of little avail in dealing with polycystic kidney.

The cases seen early almost always show a chronic inflammatory stricture of the ureter, which is probably the original cause of the dilatation. This dilatation occurs at the pelvo-ureteral junction more often than anywhere else, no matter whether the condition be acquired or congenital. The association of pyelitis with hydronephrosis appears to be invariable, and usually chronic interstitial nephritis will also be in evidence. The first intimation which the patient experiences of the presence of renal retention is likely to be pain arising from an exacerbation of the existing pyelitis. White says that there will be evidence of infection either on cystoscopy or in the urine, in a large proportion of cases, during the attack of pain. This attack is often accompanied by increased frequency of micturition. When the attack has passed there may be little or no evidence of infection.

Hydronephrosis induced by anomalous blood-vessels. A special class of congenital hydronephrosis to which Quinby called attention a few years back, is that where the obstruction is due to the presence of an abnormal blood vessel supplying the kidney. This author reported six cases all occurring in adolescents or young adults. The chief, and often the only, symptoms accompanying this form of hydronephrosis are intermittent attacks of pain. Between these crises the patient will be perfectly well and in most instances in excellent physical condition. Operative treatment is the only means of relief. Ligation and section of the anomalous vessel often suffices in those patients who have come under observation early enough to still possess relatively undamaged kidneys. Where the obstruction has been complete for a considerable period, all functioning renal tissue will be destroyed and excision of the kidney the only resort. Sometimes a plastic operation upon the dilated pelvis may be carried out. The type of operation described by Quinby where the kidney still possesses a certain amount of functional ability, is one which disassociates the aberrant vessel from the excretory passages. A short incision from the pelvis to the ureter is thereafter sewn together, following the fashion of the Heinke-Mikulicz pyloroplasty. This is advantageous if there be a stricture or valve-formation at the pelvic outlet. Free section of the ureter with re-implantation into a lower part of the pelvis, well away from the anomalous vessel, has worked well in a number of cases.

Diagnosis. The tumor caused by retention of urine is often one of the first observed signs of a number of renal conditions of widely differing etiology. In making the diagnosis the means of examination already mentioned in connection with calculus, tumor or stricture will have to be brought into service. No one of these is more important than ureteral catheterization and pyelography. Often the simple passing of the catheter will dilate a ureteral stricture and at once empty a much-distended pelvis, with complete relief of all symptoms. More often, the condition will have progressed too far for such simple measures to be curative. The injection of an opaque medium, or the employment of Uroselectan will be necessary in order to demonstrate the amount of pelvic distention. The mere measuring of the amount injected will not give an accurate estimate of the extent of the dilatation because the pelves of perfectly normal kidneys vary greatly in capacity in different individuals. To be sure of complete filling when the injection method is employed, the maneuver must be continued until the patient complains of pain, *but must then be stopped immediately.* In the normal pelvis the outlines of the minor calyces as seen in the pyelogram will be clear cut and distinct, whereas in the hydronephrotic kidney, the minor calyces will show up dimly with their outlines uncertain and distorted. The bases of the major calyces will show widening, giving what Keyes humorously termed the "plug hat" outline. The pelvis itself will be markedly enlarged. The further the condition has progressed, the more marked will this widening appear and the less distinct will be the outline of the minor calyces, until in advanced cases they will have disappeared completely. As these changes gradually take place the angle formed by the ureter at its point of entrance into the pelvis becomes more and more acute, which has been pointed out by Nichols as a very important diagnostic point in differentiating a hydronephrotic kidney from one that is normal but possesses a pelvis of unusual size. He suggests that in some cases injection of both sides for comparison may be necessary. In a normal case the two kidneys will have pelves of equal size, but with unilateral hydronephrosis, only one pelvis will be of unusual dimensions.

The advanced cases will usually be in evidence without resort to pyelography. When it is done the following changes will be noted: Marked pelvic dilatation; broadening of the major calyces, together with so much shortening that — to use Nichols' own words — they will be shortened to such an extent that they may present only a shallow indenture into the smooth contour of the hydronephrotic sac.

Treatment. The measures for the relief of hydronephrosis are as varied as its causes, though the necessity of emptying the retained content is, of course, evident in all types of the affection. Properly speaking this condition is only a manifestation of some renal lesion such as stone, stricture and so on, so should not be classed as a disease entity. The too frequent removal of the hydronephrotic kidney should be discouraged. The recuperative power of renal tissue is so great that even when but little functioning surface remains, the restoration of normal drainage will often be followed by rebuilding of the injured areas with continued usefulness of what seemed a hopelessly damaged organ.

RENAL FISTULA

Fistula of the kidney region, although by no means an uncommon sequel to operative treatment, is a decidedly unusual finding when no previous intervention has taken place. Yet scattered through the literature of the past ten years are to be found occasional reports which would indicate that such lesions are likely to be encountered at some time or other by the renal surgeon and their consideration may easily become of extreme importance when one is least prepared to cope with them.

Etiology. Tuberculosis is the most common cause of renal fistula, as of those in communication with other parts of the body. So-called *autonephrectomy* — complete destruction and walling-off of the kidney — may make itself evident by the opening up of a sinus from the affected renal area to the surface. Occasionally a traumatized kidney may pass through the same changes. Even when there is no definite history of previous renal tuberculosis the suspicion must remain that the traumatized organ may have already suffered pathologic alteration. In a case reported by Stern, a man of 30 had for four years experienced vesical irritability and occasionally, incontinence. He sustained a severe blow in the right flank and shortly thereafter pus pointed in two places, just under the last rib and about an inch above the iliac crest. An abscess diagnosed as retroperitoneal was opened and drained. The resulting sinus failed to heal and seven months later, injection of the sinus and the ureter of that side with an opaque medium gave a pyelogram showing the two streams meeting with no outline of any renal pelvis. Argyrol injected into the sinus appeared in the urine an hour later, but a catheter passed the full length of the ureter failed to bring away any urine. The kidney had apparently been completely destroyed. All connection between the sinus and the bladder could be readily eliminated. The only treatment given was free irrigation with Dakin's solution. The fistula eventually healed, and a year later the patient was in excellent health.

Residence in the tropics and malaria, but nothing suggestive of tuberculosis, was included in the history of the patient reported by Aubert and Vernéjouls of Marseilles. He was a prisoner of war in Germany for some three years and while in the detention camp was injured by a fall, the blow being received in the right hypochondrium. This was followed by an attack of hematuria enduring for three weeks. Thereafter a tumor appeared in the right periumbilical region. This remained symptomless for almost a year. There was then a sudden attack of chills, fever and digestive disturbance with evidence of pus accumulation near the tumor mass. Incision in the umbilical region brought away a large quantity of pus and more continued to drain through the sinus, which remained open. At no time was there any disturbance in urination, nor untoward manifestations in the urine. Septic phenomena continuing in evidence, it was decided to operate, the tentative diagnosis of hydatid cyst which had ruptured, being made. In the complete absence of urinary symptoms connection with the kidney was not even considered. Marsupialization of the abscess pocket failed to effect any improvement. Finally bismuth injection and roentgenography demonstrated that the sinus had its origin in the right renal region. At a second intervention a huge pyelonephrotic kidney — practically a pus-filled shell — was removed with great difficulty because of adhesions.

In a very similar case reported by Guy in *The Lancet*, calculi were found at the bottom of the sinus and when these were removed the wound closed without much delay. There were no urinary symptoms in this case, the reporter remarking that it fulfilled the classic descriptions of the condition in this respect. A fistula of undoubted tuberculous origin described by Roubier of Lyon in 1922, presented several peculiarities which illustrate the difficulty likely to be encountered by the surgeon confronted by these fistulæ. The patient, a boy of 19 who had served as a soldier, was operated for a pus collection diagnosed as a subphrenic abscess. All the symptoms present were referred to the respiratory tract. There was no disturbance of the urinary function, nor pain in the renal region. *After* this intervention the sinus failed to heal and eventually blood appeared in the urine. This was coincident with the manifestations of a subacute pulmonary tuberculosis to which the patient succumbed. Autopsy showed a cold abscess situated below the right kidney. It communicated on one side with a large bronchus and on the other with a cavity in the upper pole of the kidney. The entire kidney was infiltrated with tuberculous caseation. The bladder was likewise extensively affected by the tuberculous process. Yet during life the existence of the urinary infection had not been noticed. All attention had been directed toward the pulmonary condition and urinary symptoms were wholly absent until the very last stages of the disease.

It was pointed out in the discussion of one of these French cases that routine examination of the urinary tract would have revealed the renal connections of these fistulæ, even in the absence of frank urinary symptoms. In any doubtful case such diagnostic precautions should never be neglected. With the varied means of diagnosis now at our command it would seem that the general surgeon ought not to remain long in ignorance regarding these lesions. Failure to recognize their true nature indicates a lack of thoroughness in examination for which there is no justification.

Treatment. The method of handling such a fistula when its ramifications have been made plain will depend altogether upon its cause and the state of the kidney with which it communicates. In Guy's case, removal of the calculi was sufficient to bring about healing, but in all the others the kidney had been practically destroyed and nephrectomy offered the only hope. The ordinary measures for the eradication of sinuses do not appear to have been efficient in the reported cases. Exploration in one led to nephrectomy by the transperitoneal route (Aubert and de Vernéjouls). This particular procedure is inadvisable at any time, and was especially so here, in view of the infected condition of the kidney, the relations of the blood vessels and the many adhesions which had formed. The history of prolonged hematuria after trauma to the abdomen was sufficiently striking to have demanded an investigation of the urinary tract, which would have readily established the diagnosis. Vol. 3. 331.

SURGICAL TREATMENT OF BRIGHT'S DISEASE

Decapsulation of the kidney has for many years had an established place in the therapy of certain so-called " medical diseases " of the renal organs. After its introduction by Edebohls it was widely employed for a time, then fell into more or less disrepute — largely because of indiscriminate and unwarranted application. At present it has somewhat regained its former popularity and when indicated, is a very great aid in the control of certain types of renal disease.

Types of disease in which surgery is indicated. To use surgical measures intelligently it is absolutely essential that the medical attendant be thoroughly conversant with the varying types of renal disease with which he may be presented. He must distinguish between involvement of the renal circulation and a lesion in the tubular portion of the kidney. In the first instance we have nephritis, and in the second, nephrosis. These are distinct pathological entities and must be separately considered. Nephritis is a disturbance of the proper circulation in the glomeruli — the " waterworks " of the kidney. The medical procedure in this disease is to reduce the patient's fluid intake as much as possible — that is, put the parts at rest. If this has no permanent effect it may be necessary to make use of surgical measures. Removal of the kidney's fibrous capsule relieves the congestion and stagnation induced by acute nephritis, and was formerly thought to establish a collateral circulation as a part of nature's attempt to repair the surgically inflicted injury. Though this explanation is now known to be erroneous, the probability remains that the sympathetic fibers of the capsule are destroyed, on account of which the glomeruli are enabled to return to normal.

As nephrosis is actually a form of renal degeneration, the destruction of nerve complexes will have comparatively little effect on the tubular system. Even leaving the capsule intact and merely freeing the kidney from adhesions caused by a coexistent perinephritis is not so likely to bring about good results as will ensue when we are dealing with nephritis.

In a few cases where the disease process is wholly unilateral and has advanced to such a degree that the organ is functionally useless, and perhaps also, is acting as a focus of infection which will impair the ability of the opposite kidney, nephrectomy may be advisable. No general conclusions in regard to the wisdom of such a procedure can be drawn. Each case will have to be very carefully considered on its individual merits, and the decision reached after conservative weighing of all the factors involved. The need of great caution is emphasized by such cases as that reported by Kammerer, who cut down upon a nephritic kidney with the intention of removing the cortex only. Finding the tissues infiltrated by small abscesses, and the opposite kidney to all appearances normal, he decided to perform a nephrectomy. The patient died of renal insufficiency within ten days. When the remaining kidney was sectioned at autopsy it was found to be in quite as bad a condition as its mate.

Other applications of surgery in renal disease. Decapsulation and nephrolysis have occasionally been employed in eclampsia, but the procedure is not generally favored and is somewhat questionable. In desperate cases of bichloride of mercury poisoning decapsulation has been hailed as a life-saving measure. The report recently made by Quinby is not at all favorable as to the benefits which decapsulation produces in these more or less unusual types of nephritis, and his opinions are probably fairly indicative of the attitude of experienced renal surgeons generally.

ANESTHESIA

In no branch of surgery is the anesthetic of such importance as in that of the kidney. It is not too much to say that progress in renal surgery has directly kept pace with progress in anesthetizing methods, and the great advances of recent years are due, not so much to increase in skill in surgical procedure generally, as to improvements in anesthetics and the way in which they are now administered.

Choice of anesthetic agent. The choice of the particular anesthetic to be used in any given operation upon the kidney is inevitably influenced by a number of factors such as age, condition of lungs and heart, estimated renal function, and many others. In all interventions upon the kidney the special problem presented by the condition of both organs makes the responsibility of him who selects the anesthetic even greater than in other surgical procedures. In operating upon any organ the effect upon the kidneys must always be reckoned beforehand. When the kidney itself must undergo the inevitable trauma of surgery the cost must be counted with metriculous care.

Because so many subjects of renal interventions are "poor risks" from the surgical viewpoint there has of late been a very decided trend toward the employment of regional anesthesia, rather than a generalized narcosis. At the Brady Foundation of the New York Hospital many cases are now being operated under paravertebral anesthesia, which is considered as especially indicated where there are cardiac lesions, either endocarditis or myocarditis. It is considered indicated in patients presenting advanced arterio-sclerosis upon whom inhalation anesthesia is a very serious strain, as well as all forms of pulmonary affection, tuberculosis in particular. Also in patients presenting bilateral renal disease, as a crippled kidney may be called upon to do the work of both sides while its fellow undergoes operation. Under such conditions the added strain of ether anesthesia which is very irritating to renal tissue, might bring about a rapidly fatal termination.

Dangers of paravertebral anesthesia. Unfortunately, enthusiasts are likely to overlook the very real dangers which attend the use of regional anesthesia. The only one regularly mentioned is the impossibility of withdrawing the anesthetizing agent after it has once been injected. My own experience has demonstrated quite conclusively that the pitfalls to be avoided are quite as deep and numerous as those which attend the inhalation methods, even in patients with contraindicating complications. Novocaine, the drug ordinarily employed, while far less toxic than its predecessor cocaine, is by no means innocuous, as studies by Roth, Hatcher and others have abundantly demonstrated. Roth found that the depressing effect of novocaine on blood pressure and respiration in animals makes it necessary to use caution in administration in clinical cases where the blood pressure is low, or the heart is at fault. Every effort should be used to avoid the entrance of the drug into the circulation, as its toxicity is thereby much increased. Individual susceptibility varies so greatly that a wide margin of safety in untried individuals is absolutely essential. In the aged especially, susceptibility seems to be much increased.

It has been my personal experience that most patients — unless extraordinarily phlegmatic — find the administration of paravertebral anesthesia somewhat painful. Even when anesthesia is supposed to be complete throughout the operated area any traction upon the peritoneum is sure to produce pain. These considerations have led me in cases where inhalation anesthesia is not absolutely contraindicated, to continue the employment of the older methods, relying upon certain refinements of the technique of application to obviate most of the difficulties ordinarily associated with these less novel procedures.

Spinal anesthesia. Though spinal anesthesia has been employed more or less regularly in certain types of urological operations during a long period, it is only recently that its use has received the sanction of thoughtful operators. The method demonstrated by Pitkin has now been before the medical profession for several years, and has so far proved its superiority over any that have gone before as to remove in large measure the prejudice heretofore entertained against this form of anesthesia. My personal experience with Pitkin's method leads me to say that it has so far reduced the hazards and widened the indications for spinal anesthesia as to make this procedure quite as safe and reliable as any other form of local analgesia. It has all the advantages of paravertebral induction, and is undoubtedly more convenient for the surgeon and less disadvantageous for the patient. I have found it applicable wherever regional anesthesia can be safely used. For many kidney operations it is the ideal anesthetic.

Apparatus required. Pitkin has designed several special instruments by means of which the technique he has elaborated may be more efficiently put in practice. Their employment is not essential to successful application of the method, but it is advisable to add them to one's equipment if this can conveniently be done. The *tiltometer*, attached to the operating table to do away with any guess-work in tilting the patient at the proper angle for correct diffusion of the anesthetic after its injection into the spinal canal, is not the least useful of these. The *spinal needle* is of rustless steel and has a short bevel (45°), the rear portion rounded so that it cuts a miniature trapdoor in the dura. Pitkin's own list is as follows:

1 Luer-Lok syringe, 2 cc.
1 Luer-Lok syringe, 3 cc.
1 Pitkin spinal puncture needle
1 hypodermic needle with $\frac{3}{4}$ in. safety guard
1 sterile file
Sponges
1 ampule spinocain
1 ampule ephedrine-novocaine solution
1 pair sterile gloves
1 sponge holder
Tincture of iodine, 5%

Spinocain. The solution used by Pitkin is composed of novocaine, amyloprolamine (starch paste), alcohol, strychnine sulphate and normal saline. To this he has given the name *spinocain*. The alcohol renders the solution lighter than the spinal fluid, so that the solution will float in the spinal fluid, "as does the air bubble in the spirit level." To obtain a solution heavier than the spinal fluid, the alcohol was omitted and propantriol added, which gives a compound with the specific gravity of 1.109. This will descend by gravity to the lower parts of the dura. The advantages of having two solutions of greater and less specific gravity than the spinal fluid is at once evident.

Technique. Never administer spinocain with the patient in the sitting position, and after the heavy solution has been used, never place the patient in the Trendelenburg posture. If the patient's body be raised spinocain will ascend rapidly in the spinal canal. For the heavier solution the patient should be placed in the sitting posture, or in the Fowler position so that the solution will descend.

Whichever solution be used, the spinal puncture and the injection must be done with rigid adherence to the principles upon which the technique is based. No one should attempt to use the method before studying every detail with the utmost care. Spinocain is always injected with the patient lying on the side, knees flexed, head bent forward, and back bent out. This separates the spinous processes and permits easy and painless puncture. For a right-sided operation the patient is placed on the left side, and *vice versa.* The solution being lighter than the spinal fluid, will float on the top and anesthetize the nerves of the right side first. The head of the table is then tilted to place the patient in a 5° Trendelenburg position, which is easily measured with the tiltometer. For injection of the heavier fluid the patient sits, or is placed in the Fowler position. The Trendelenburg position must *not* be used thereafter. In either instance to secure satisfactory anesthesia the spinal fluid must be aspirated and mixed with the anesthetic solution before any attempt is made at injection. The site of the puncture is previously rendered insensitive by injection of an ephedrindrine (50 mg.), novocaine (10 mg.) solution in distilled water, the purpose of the ephedrindrine being to fortify the vasomotors against the attacks of the anesthetics. In introducing the anesthetizing solution care must be taken to hold the needle at right angles to the spine so as to avoid puncturing a vein. The needle should pass between the spinous processes and the point be kept wholly within the dura.

Spinal anesthesia in kidney operations. Pitkin's method is especially effective in renal surgery. Because it is so light spinocain ascends to the crest of the spinal canal when the body is lifted on the kidney bar or other support. This produces a more intense anesthesia at the site of operation. The interspace selected for puncture is not of great importance, as the extent of the anesthesia is regulated by the degree of the Trendelenburg position employed. The needle should never be introduced above the conus medularis. Sudden death has supervened in cases where this rule was violated. Jeck, who has had special experience in using this method in kidney and ureteral operations, speaks especially of the effect noted upon blood pressure. In kidney operations when it is necessary to pull upon the pedicle, the blood pressure drops to a certain extent, but there is no need for alarm unless marked pallor, rapid respiration or vomiting is in evidence. Should any of these symptoms appear, a hypodermic injection of 0.05 gm. of ephedrine and still further lowering of the head of the table will usually bring about rapid restoration. To this author spinal anesthesia seems especially indicated when preservation of kidney function is a paramount consideration. Nephrectomies in particular, often so difficult under general anesthesia, are rendered much easier on account of the complete relaxation which spinal anesthesia gives. The violent respiratory movements so often embarrassing to the operator working under general anesthesia, are absent, and in tuberculous kidneys especially, this form of anesthesia is particularly useful.

Ether anesthesia. In a survey of five thousand cases operated under gas-oxygen and ether in about an equal ratio, Miller of Providence concludes by saying: The figures show that gas-oxygen anesthesia does not prevent the occurrence of circulatory and pulmonary complications, as well as uremia and diabetic coma in the individuals who are predisposed to those conditions. The opinion, sometimes prevalent, that all post-operative difficulties are removed by the use of gas-oxygen or any other anesthetic agent, has no foundation. It is probable that, *if the same attention had been paid to improving the technique of etherization, that has been spent on other anesthetics, ether would now be recognized as the safest and most efficient of anesthetic agents.*

The italics are my own, for the thought thus emphasized has long been present in my mind. Many devices, trivial in themselves, can be employed to increase the safety and ease of administration of ether, and it is this adaptability which makes it most desirable as a routine anesthetic for general hospital work. Much of the success of paravertebral and other regional methods depends upon clever psychic work on the part of the attendants, some of whom are particularly trained for this service. How much do we hear about the psychic atmosphere which should surround the patient about to " take ether "? Yet those who must undergo operations upon the kidney are often mentally as well as physically depleted and need all the moral support which can be rendered them. For this reason, small precautions taken before the anesthetic is administered, not only serve to make the post-operative reaction less distressing, but also help the patient by carrying the suggestion that his comfort and welfare are especially the care of the anesthetist.

A few drops of sterile castor oil in the eyes and anointing the lips and nostrils with sterile vaseline, will save much discomfort the next day. When the surgeon has finished his work it should be the anesthetist's concern to wash out the stomach with solution of soda bicarbonate and to administer oxygen until consciousness is re-established. If such precautions are observed, the much dreaded sequels of ether anesthesia will be largely obviated. The anesthetist should be gentle but at the same time, expert in handling his subject. Post-operative parotitis — formerly supposed to depend solely upon mouth infection — may very often be activated by rough handling of the unconscious patient's jaw.

Paravertebral anesthesia. The method of paravertebral anesthesia employed in the kidney operations done at the Brady Foundation, New York Hospital, is as follows:

The patient is seated on the side of the table, his feet supported and his hands resting on his knees, or on the shoulders of an attendant. His head is inclined and back slightly bent. One per cent. procaine solution is employed to make a line of infiltration extending from a point just below the twelfth costovertebral angle, and 2 cm. from the midline, to the level of the eighth rib. All subsequent injections are made from this original wheal, these being begun by inserting the needle 2 cm. from the midline, opposite the spine of the seventh dorsal vertebra. It is pushed in until it strikes the angle formed by the lamella of that side and the transverse process. It is then carried over the ridge of the bone, the point deflected inward, and again pushed downward to a depth of about 1 cm. The needle point should now be in the area occupied by the merging nerve roots. Assured that no blood vessels have been entered, 2 or 3 cubic centimeters of the solution are injected at this point.

The same procedure is carried out from entrance points over the ninth, tenth, eleventh and twelfth dorsal vertebræ. The angle formed by the twelfth rib is well filled both above and below. With the patient on the sound side, the entire loin, skin, subcutaneous fat and muscular tissue, are infiltrated with one-half of one per cent. procaine solution, still using the original wheal as an entrance point. A man of average weight should not receive an injection of more than 150 cc. of the solution. One gram per 100 pounds of body weight is the maximum amount. All anesthetized areas should be tested before making the initial incision, and the patient's attention distracted as much as possible by a specially trained attendant. Insensibility will be established in the injected area as soon as the patient can be arranged on the table.

A very ample incision is necessary and all traction upon the peritoneum must be scrupulously avoided. If manipulation or clamping of the pedicle is felt by the patient, some solution should be injected into the tissues of the pedicle before proceeding further.

Rectal anesthesia with avertin (tribromethylalcohol). During the past five years rectal anesthesia has been receiving a steadily increasing amount of attention and employment. Gwathmey's colonic-ether-oil method had extensive clinical trial for a considerable period previous to this, but the drawbacks to this form of anesthesia are numerous, and in many cases, quite insurmountable. The recent introduction of tribromethylalcohol, popularly known as Avertin, has provided us with an agent for rectal administration which induces a very satisfactory anesthesia. This can be used where inhalation or regional anesthesia is, for any reason, inexpedient, as it eliminates pulmonary complications and has none of the unpleasant after-effects which are so much to be dreaded in certain types of surgical work. For numerous urologic procedures Avertin has proved very useful in our work at the James Buchanan Brady Foundation of the New York Hospital, where it has been used in some 75 cases. It is most satisfactory when employed as a basal anesthetic, supplemented as occasion requires by small quantities of local anesthetics or inhalation anesthesia.

Avertin is now available in this country only in fluid form. The usual dose for renal surgery when the patient is in fairly good condition is 0.1 cc. for every kilogram (2.2 lbs.) of body weight. An adult male patient may be given up to 10 cc., women 6 to 8 cc. If the patient be much debilitated, the dose should not exceed 0.08 cc. per kilo. The preparation and testing of the solution for injection into the rectum must be carried out with great care. Indeed, one of the drawbacks to this form of anesthesia is that it cannot be entrusted to any but the most competent hands. The same attention to the anesthetized patient must be given as when inhalation methods are used, and the strictest observance of all the rules and cautions laid down by those who have studied its chemical and clinical properties most thoroughly, is of paramount importance.

The routine of administration in our clinic has been as follows: A preparatory enema is given the evening previous to operation. Two hours before the time set for the intervention the patient receives a dose of morphine, magnesium sulphate and procaine; after an interval of one hour, a second dose is given. During this preliminary narcosis the room should be darkened and the patient kept perfectly quiet. The required amount of Avertin Fluid is made up in a 2.5 solution with distilled water and injected into the rectum at body temperature. The gravity method of administration may also be used with satisfaction. The absorption of Avertin by the rectal mucosa is so rapid that complete narcosis usually takes place within fifteen minutes. The patient must be left absolutely undisturbed for at least this length of time, no tests for insensibility or loss of consciousness being applied before twenty minutes have elapsed. Preceding, during and after the operation all the precautions in regard to the condition of the circulation, respiration, etc., exercised when generalized anesthesia by the older methods is being used, must be rigidly observed. Sometimes additional inhalation agents will be required to secure complete relaxation but many times this will not be necessary.

The recovery of consciousness resembles awakening from deep sleep. There is no nausea or excitement, and all the unpleasant after-effects heretofore considered inseparable to anesthesia produced by almost any method, are conspicuous by their absence.

Avertin has especial advantages when the patient is exceptionally nervous and hysterical but presents conditions contraindicating the use of ether or nitrous oxide. As it is detoxicated in the liver, any lesions of this organ offer a strong contraindication to its use. As regards the condition of the kidneys, we have found that the rules applying to other anesthetics operate also with Avertin. The renal surgeon is obliged to exercise especial caution at all times, and will find this mode of inducing anesthesia very convenient and satisfactory for much of his work.

GENERAL CONSIDERATIONS IN RENAL SURGERY

If the diagnosis has been made with the aid of modern methods, the general condition of the patient coming for renal surgery will have been thoroughly investigated and a detailed report as to the exact state of his urinary tract will be at hand. Before undertaking any intervention upon a kidney it is absolutely essential to have information concerning the one which is *not* to be operated. If this information is not at hand, it may be necessary to explore the opposite renal region in order to determine how much functioning renal tissue the patient will have left when the surgeon is through with him. Delay thus occasioned may very well be dangerous or even directly fatal. Except in emergencies — traumatic accidents and the like — there is no excuse for omitting to make this thorough preliminary survey. The estimation of renal function is of especial importance. It is not enough to know that the opposite kidney is present and functioning, though this, of course, is likewise absolutely essential. We are taught by such a case as that reported by Bugbee and Losee several years ago, that anomalies may exist which will upset all the surgeon's calculations. In the case referred to, the ureteral orifices were both present in normal position. From one side urine loaded with pus and tubercle bacilli was obtained. That from the other side was healthy. Nephrectomy was performed on the side where tubercle bacilli had been demonstrated. The patient in a few days died of uremia, and autopsy disclosed the fact that the ureters were crossed, the left kidney emptying into the right side of the trigone, and *vice versa*. Only pyelography would have revealed this anomaly before operation, and in the face of what appeared to be indisputable evidence, no surgeon could be blamed for omitting to use it. Yet the lesson carried by this grave mistake is none the less obvious.

Approach to the kidney. When the fully anesthetized patient is laid on the table upon his sound side, the body should be brought close to the table's edge and a sandbag or cushion placed beneath the loin. Thus the side to be operated upon will be forced upward, increasing the interval between the iliac crest and the last rib. For extraperitoneal incision the surgeon takes up his position at the patient's back, with his assistant opposite; for transperitoneal incision, the position of the patient and the surgeon's place are the same as for operation upon the median abdominal region. The ribs may be still further separated by flexing the leg of the sound side at both thigh and knee. The opposite leg is kept straight and both legs strapped in position. The upper part of the trunk must be held steadily, and this is usually accomplished by padded rests with which the special urological tables are provided. The unconscious patient can, of course, be restrained more completely than one anesthetized by the spinal or paravertebral method. In any event, firm support and immobility of the body are essential.

Anatomical landmarks. Before making any incision the operator should make sure of his position by locating all the necessary anatomical guide points. The ribs should be counted from above downward, for many apparently normal individuals are without a twelfth rib, and in numerous others a thirteenth rib is present. If it be assumed that the twelfth rib is present incision may invade the pleura if it should happen to be absent. If the patient possesses a thirteenth rib an incision carried only to the twelfth rib would give too contracted an opening. The tips of the eleventh and twelfth ribs should be found and indicated, and the location of the crest of the ilium, the anterior superior spine, and the anterior edge of the erector spinous process definitely established.

Retroperitoneal lumbar exposure. The ordinary route of access to the kidney is by the lumbar route, cutting through the superior lumbar trigone. This is the least resistent portion of the space bounded by the twelfth rib and the sacro-spinalis muscle. The incision is begun at the anterior border of the erector lumbar muscles, and carried downward and forward, running parallel to the twelfth rib. It is usually terminated at a point an inch to an inch and a half (2.5 to 3.8 cm.) above the crest of the ilium. If extra room is necessary the incision may be carried all the way to the iliac crest and also directed somewhat more toward the anterior superior iliac spine, ending at the outer side of Petit's triangle. If the patient is large bodied or extremely fat, the incision may be curved downward for perhaps an inch from the iliac crest, terminating directly over the anterior superior spine. In thin patients, or where the operation is not expected to be extensive, a shorter incision will be sufficient.

Rovsing's incision. The late Thorkild Rovsing, an eminent Scandinavian surgeon, objected to the classic incision, claiming that it produced a narrow and awkward opening. He placed his patient lying on the back, the edge of the table coinciding with the free border of the erector spinæ

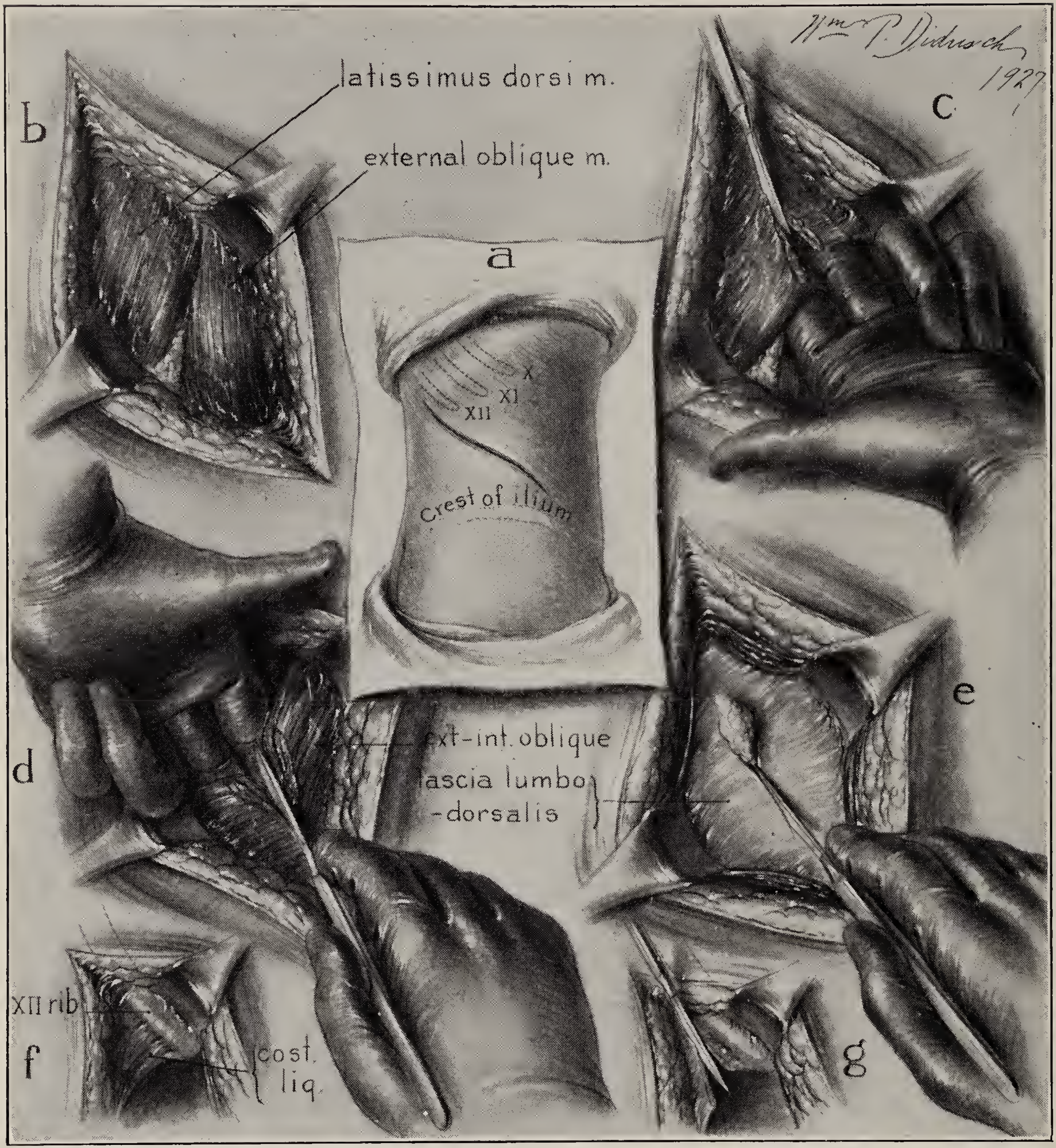


Fig. XVIII. Extraperitoneal nephrectomy. (*a*) Skin incision above tip of 12th rib and running downward to crest of ilium. (*b*) Lastissimus dorsi and external oblique exposed, showing Petit's triangle. (*c*) Cutting latissimus dorsi. (*d*) Division of external and internal oblique. (*e*) Incision of lumbo-dorsal fascia, showing protrusion of retroperitoneal fat. (*f*) Costo-vertebral ligament exposed. (*g*) Division of costo-vertebral ligament.

muscle. This, he claimed, made the lumbar region more readily accessible for the incision. He began his incision midway between the twelfth rib and the iliac crest, continuing forward to the border of the rectus, and sometimes — if the ureter had also to be exposed — around the anterior superior iliac spine obliquely downward toward the symphysis pubis. This, he argued, rendered him independent of the narrow space between the twelfth rib and the iliac crest, as his hand could be freely introduced up around the kidney in the retroperitoneal space, enabling him to isolate it and bring it whole and uninjured outside the wound. In tuberculosis and malignant growths, he regarded this as especially important, as the implantation of tubercle bacilli or cancer cells can thus be obviated.

Deepening the incision. On deepening the initial incision one cuts through the fascia and subcutaneous fat, exposing the latissimus dorsi behind and the external oblique in front. In the angle formed by these two muscles is situated the upper portion of Petit's triangle, which appears as a slight depression below the surrounding fascia. This is obliquely incised with a very sharp scalpel. Or the outer border of the latissimus may be drawn backward and very slightly upward, thus exposing the lumbar trigone without cutting in upon the latissimus. This is sufficient in cases not requiring extensive exposure, but more often some cutting will be necessary. The usual way of opening the aponeurosis forming the floor of the trigone is by blunt dissection with the finger, or thrusting in a closed forceps which is then opened, forcing the muscles apart. Sharp dissection is better when spinal or paravertebral anesthesia is being employed, separation being accomplished by the fingers or forceps after incision by the scalpel. Combined sharp and blunt dissection may be practiced until the opening has been enlarged sufficiently to permit entrance for the surgeon's hand. The Mayo scissors may be used for exposure of the surface of the kidney by freeing it from retroperitoneal fat and its own fat capsule. These should be reinforced by the fingers. Dissection should be carried out as near the quadratus lumborum as possible, incising the connective tissues near its border and proceeding thence inward toward the renal pedicle. This runs less risk of injury to the peritoneum most closely in contact with the outer aspect of the kidney. If there be abundant fatty tissue it will be wiser to trim it off with scissors to keep the view unobstructed. If branches of the ilio-hypogastric and ilio-inguinal nerves appear during the dissection of the fatty tissue, they should be carefully avoided.

If it be necessary to enlarge the wound — as may happen in large men or the very fat of either sex — the peritoneum can be pushed away by carefully inserting the fingers beneath the muscles of the abdominal wall. These muscles are then incised obliquely, parallel to the iliac crest, for as great a distance downward and forward as may appear necessary. The connective tissue first encountered contains but a few minor blood-vessels, and bleeding from these seldom requires any attention. All vessels of any size should be clamped as encountered, and carefully ligated. Hemorrhage is likely to be free when the ligament of the twelfth rib and

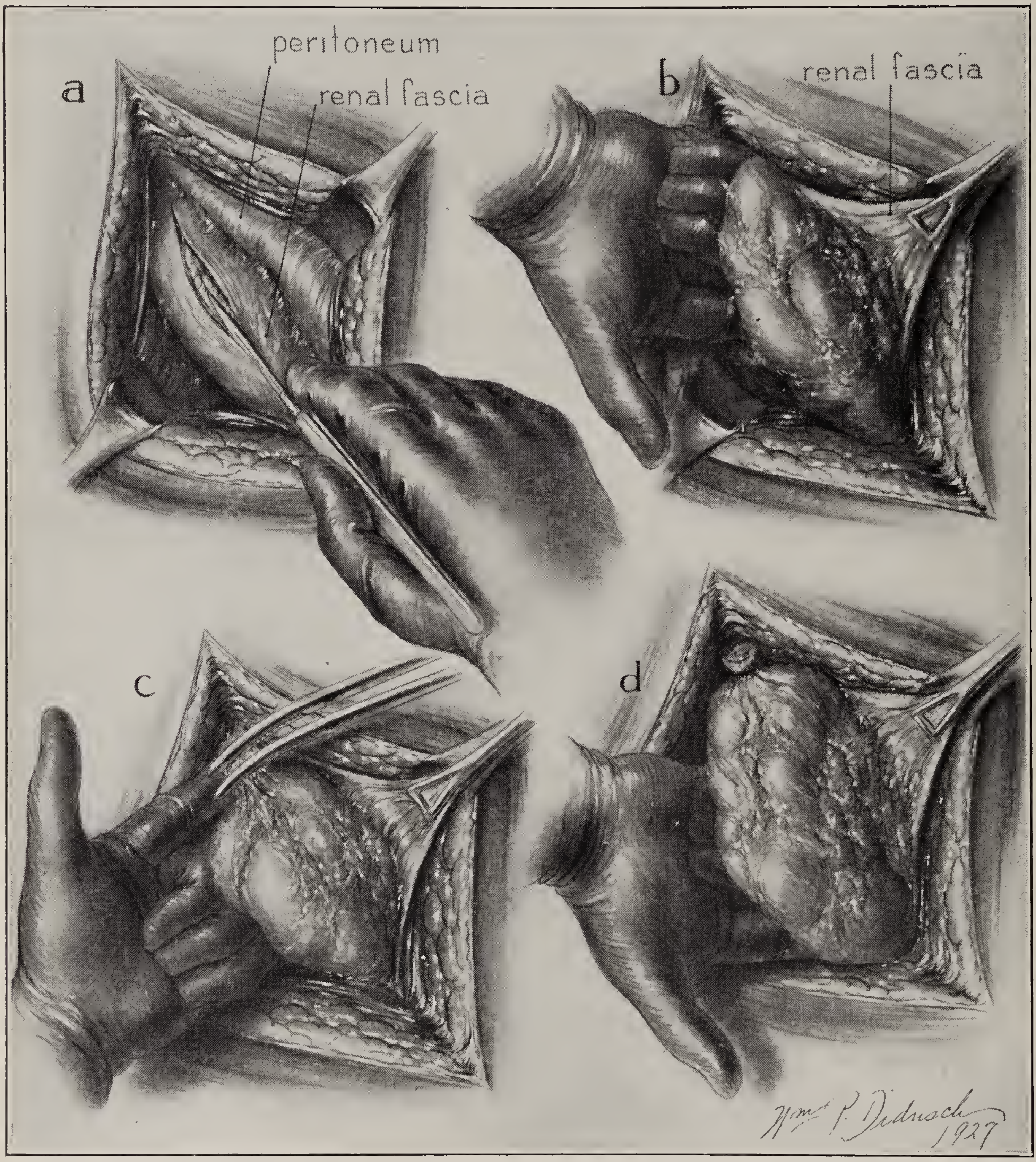


Fig. XIX. Extraperitoneal nephrectomy. (*a*) Incising the renal fascia showing retroperitoneal fat. (*b*) Anterior and lateral freeing of kidney. (*c*) Clamping adhesions and freeing upper pole. (*d*) Freeing lower pole.

the serratus muscles behind its tip are divided in enlarging the upper angle of the incision. If the finger be inserted below the twelfth rib so as to push both diaphragm and pleura upward before the ligament and muscles are cut, it will be easier to clamp the vessels. This maneuver enables the ligament to be cut some distance from its rib, and is an additional safeguard against injury to the pleura.

Delivery of the kidney. When the kidney has been freed from its fatty capsule and the incision enlarged sufficiently to permit the hand to enter, all vessels likely to produce embarrassing hemorrhage properly ligated, and pleura and peritoneum left uninjured, the organ may be lifted up into the wound for inspection. There must be absolute assurance that the whole surface has been freed up to the pedicle. In lifting the kidney great care must be exercised not to bring too much traction to bear upon the pedicle as damage to the important blood vessels contained in this portion of the organ might have immediately fatal results. The likelihood of encountering anomalous blood-vessels must ever be borne in mind. The poles of the kidneys should be freed very cautiously and the organ gradually mobilized, the tissues being carefully inspected before they are severed. The surgeon should also be alert to detect the pulsation of a possible anomalous artery.

Delivery may be accomplished with a specially designed instrument, or it may be done with the operator's fingers. The preferred method is that which induces less tension upon the renal pedicle, and this depends upon the skill and judgment of the operator. Before attempting to mobilize the kidney it is well to locate the ureter. This can usually be done by retracting the peritoneal covering and palpating for it with the fingers. When pyelotomy is to be done, the ureter may be isolated and a tape passed under it to facilitate its manipulation.

Other peritoneal exposures. What is known as the König angular lumbo-abdominal incision is begun about three-quarters of an inch (2 cm.) below the twelfth rib at the erector spinæ's outer edge, carried vertically downward and very slightly outward along this edge, to a point just above the crest of the ilium. From this point the incision curves slightly forward and upward, being carried in a straight line toward the umbilicus. It terminates at the outer edge of the rectus muscle. The underlying tissues are exposed in order, great care being taken to preserve the nerves as far as possible and to push the peritoneum ahead of the instruments by means of which the tissues are being separated. This is done by inserting the fingers as soon as the peritoneum is exposed, detaching it and holding it out of the way. This exposure gives abundant room for manipulation, but is so extensive that weakening of the abdominal parietes is likely to be induced.

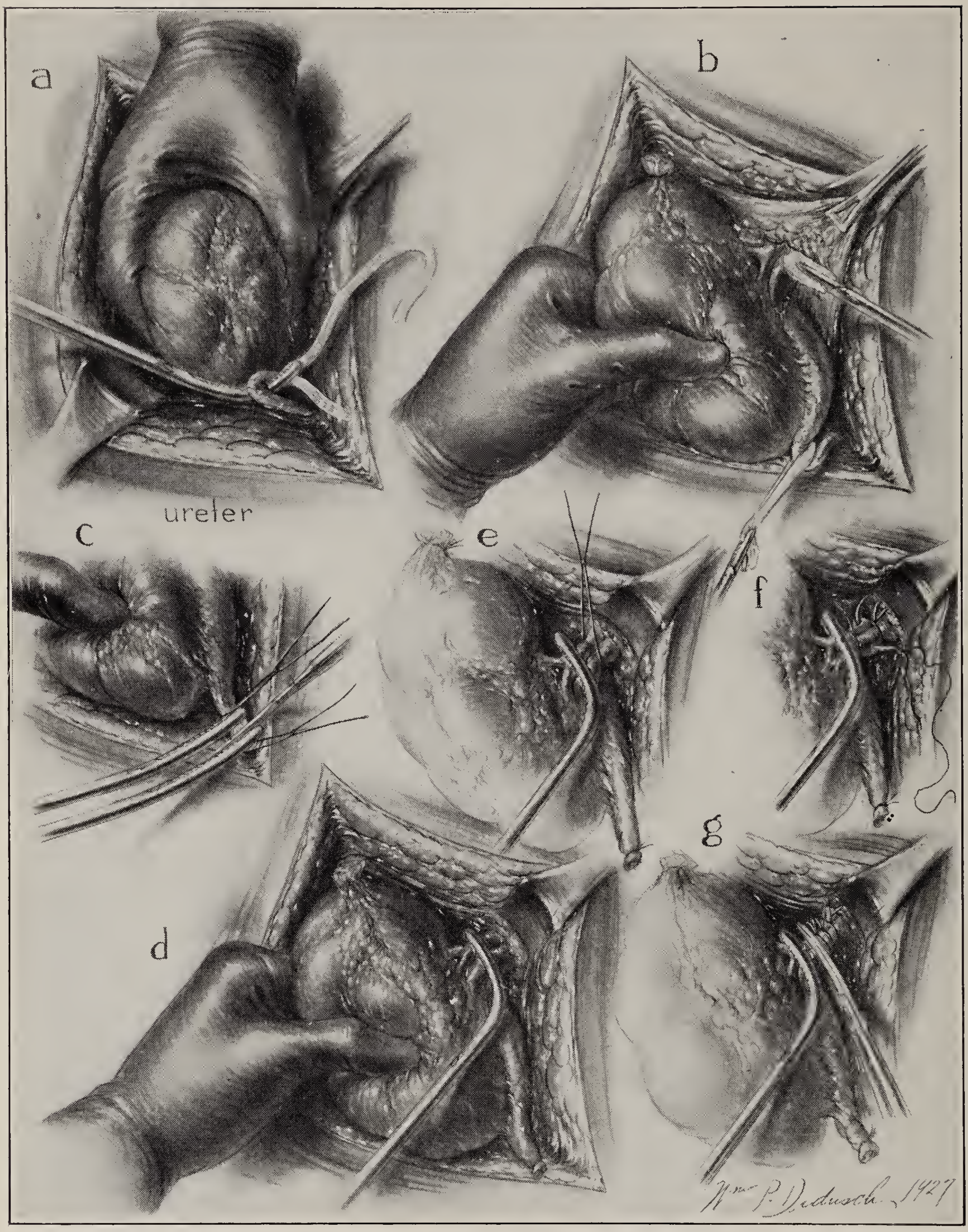


FIG. XX. Extraperitoneal nephrectomy. (*a*) Kidney held up — ureter located — passing tape with clamp. (*b*) Dissecting fat from pedicle. (*c*) Ureter is divided between clamps and then ligated. (*d*) Pedicle with first clamp in position. (*e*) Second clamp placed and first clamp removed; first tie being carried around the portion of pedicle crushed by first clamp. (*f*) Pedicle with two ligatures in position and fixation suture about to be applied. (*g*) Division of pedicle.

Anterior lateral incision. Another method of reaching the kidney without invading the peritoneum is by an anterior lateral incision, placing the patient on his back. Sometimes this incision is vertical along the semilunar line, made T-shaped by the addition of an obliquely curved transverse cut, paralleling the twelfth rib. The horizontal portion of the T starts from the other limb at a point nearly in line with the umbilicus, and is carried forward as far toward the lumbar trigone as appears desirable. This incision has the very serious objection that if made long enough to give ample exposure of the kidney it will do grave injury to the rectus muscle by damaging its nerve supply. Paralysis of this muscle is almost certain to occur. The high transverse incision which cuts across the eleventh rib is not to be recommended, though some operators employ it when called upon to remove large tumors. It is practically certain to damage the eleventh intercostal nerve.

When either of these incisions is employed, the tissues forming the wall of the abdomen are incised as far as the peritoneum, but this membrane is not invaded. Instead, the peritoneum is very carefully stripped back from the abdominal wall, which can be done by introducing the fingers at the cleavage line between the connective tissue plane and the peritoneum which it holds rather loosely against the abdominal wall. While this separation is being accomplished the viscera inside the peritoneal sac must be gently retracted toward the median line and kept out of the way by means of gauze pads held in place by retractors. The fatty envelope of the kidney is separated as in other procedures, though it is not so thick on this aspect as that encountered in the lumbar approach. The ureter clings to the peritoneum on its posterior aspect so that raising this tissue will dislodge the duct from its normal position. Special attention must be given to the pedicle when reaching the kidney by this route, as the large vessels are even more likely to be traumatized and before any intervention upon the kidney itself can be begun, must be clamped or otherwise safeguarded against accident.

Burnam's "barn-door" incision. When a large tumor must be dealt with or there is other reason for desiring an extra amount of space for manipulation, partial excision of the eleventh and twelfth ribs may be called for. The "barn-door" incision is started over the superior lumbar trigone and carried forward, parallelling the twelfth rib. It is then extended forward and upward parallel to the arch of the costal cartilages. Two temporary flaps of the lower chest wall are formed by transverse bisection of the last two or three ribs. This division is made near the superior lumbar trigone. This approach also is open to the objection of severe injury to the nerves which must be severed, with consequent paralysis of the muscles they supply.

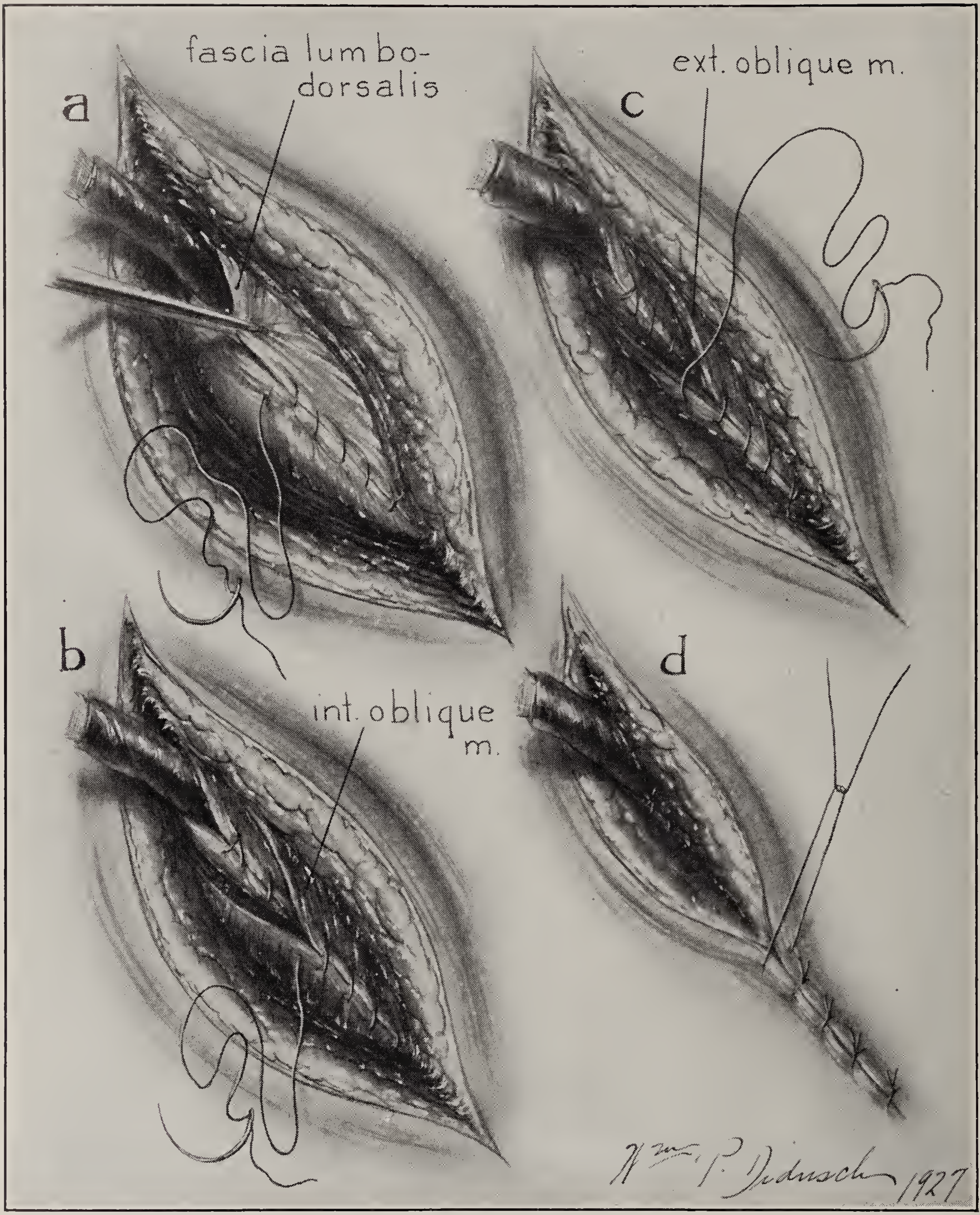


FIG. XXI. Extraperitoneal nephrectomy. (*a*) Suture of fascia lumbo-dorsalis; drain in place. (*b*) Suture of lumbo-dorsalis completed; transversalis and internal oblique muscles being sutured. (*c*) Suture of external oblique muscle. (*d*) Skin sutured.

Mayo incision. The nephrectomy incision used by W. J. Mayo and regularly employed at the Mayo Clinic is claimed to combine the advantages of both posterior and anterior incisions, and to provide greater facilities for manipulation of the kidney. It is begun over the eleventh rib, two and one-half inches external to the spines of the dorsal vertebræ, well forward on the flank. It is then carried in a crescentic line backward and upward to the point of articulation between the last rib and the vertebræ. It must extend far enough forward to give good exposure of

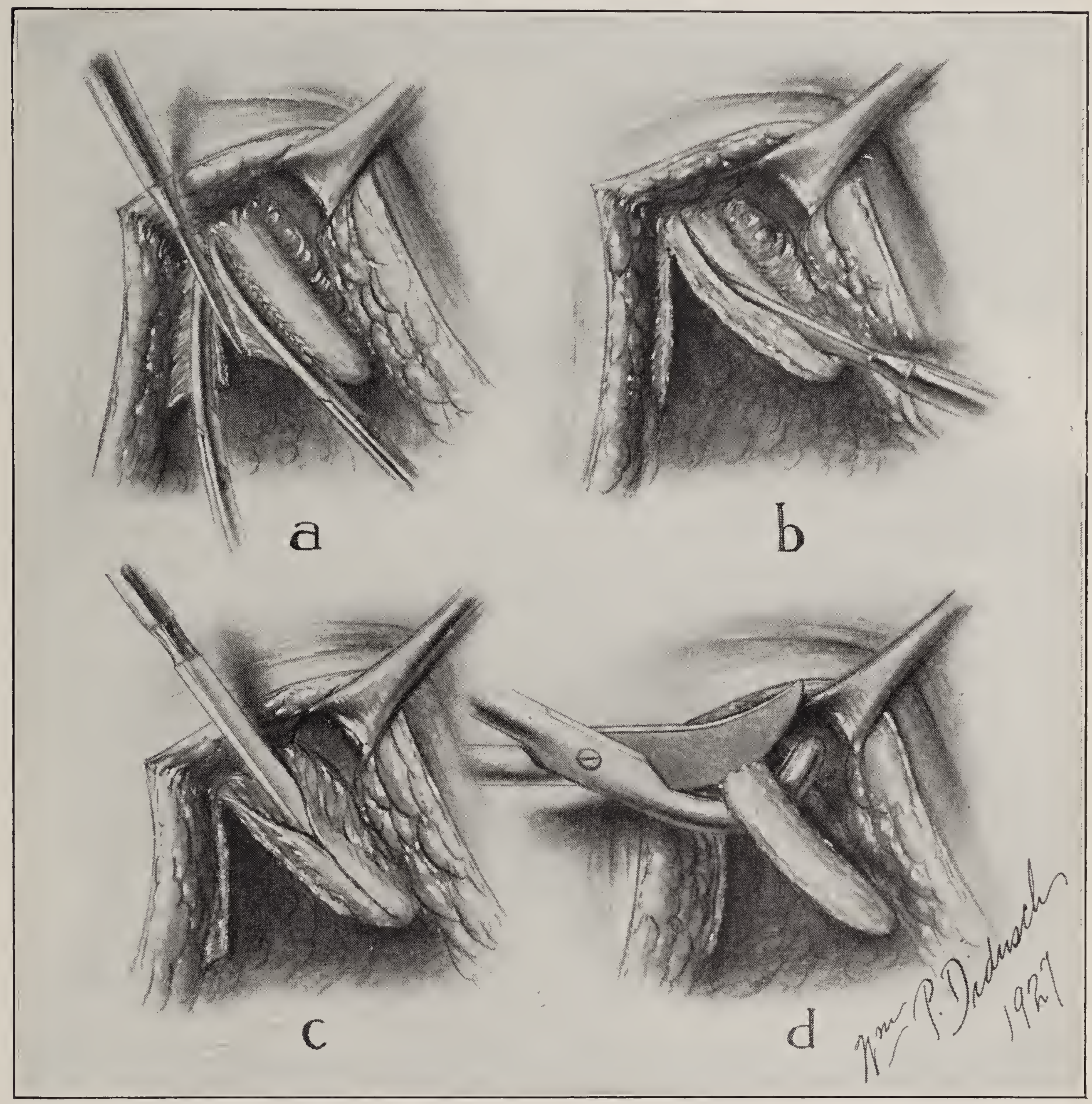


Fig. XXII. Resection of 12th rib. (*a*) Dividing costo-vertebral ligament. (*b*) Incising periosteum. (*c*) Scraping or removing periosteum from bone. (*d*) Cutting rib.

the pedicle — should this structure be short or the kidney lie unusually high. It is claimed that the important nerves can all be seen and kept out of harm's way while the ureter can be readily isolated and — in tuberculous cases especially — prevented from soiling the wound. This last is accomplished by fastening the ureter outside after it has been severed, or threading it through a rubber tube. When the kidney is not to be removed this extra attention to the ureter may not be required.

TRANSPERITONEAL EXPOSURE

For the removal of large tumors, and occasionally for other reasons, it may be advisable to approach the kidney by way of the abdomen. The patient is prepared and placed on the table as for the median abdominal section. Young makes a T-shaped incision, one branch of the T being along the inner border of the rectus, about half an inch from the median line, and the other running transversely, passing out at right angles just under the costal margin. The longitudinal incision extends along the inner border of the rectus from the costal border to within two inches of the pubes. The abdominal viscera as they are encountered are retracted and held out of the way by pads after cutting through the posterior fascia and peritoneum. When the kidney is reached it is carefully palpated, special attention being given to the pedicle in the case of malignant tumor, as not infrequently the process will be found to have extended into its large vessels.

Combination of the vertical midline incision with a transverse one is recommended by Hugh Cabot for the removal of large tumors. He believes that this approach damages fewer structures and gives a more satisfactory abdominal wall after healing than can be obtained by any other approach. He also recommends it where one must deal with abnormalities of kidneys or ureters, or any other condition where some plastic work will probably have to be undertaken. The incision should be started well back in the loin, close to the anterior border of the group of erector muscles. It is then passed not far from the lower border of the twelfth rib, inclining slightly downward until it attains the median line in the umbilical region. As the course of this incision does not traverse any important nerve trunks there will be no resulting paralysis of the rectus, or other muscles. A second incision made in the midline and carried upward as far as necessary permits the raising of a triangular flap which gives free access to all the content of the upper abdominal quadrant of that side. The peritoneum is lifted from the posterior wall, carrying with it the colon and its mesentery. By turning this flap of peritoneum inward, the rest of the intestinal tube is kept out of the field very satisfactorily.

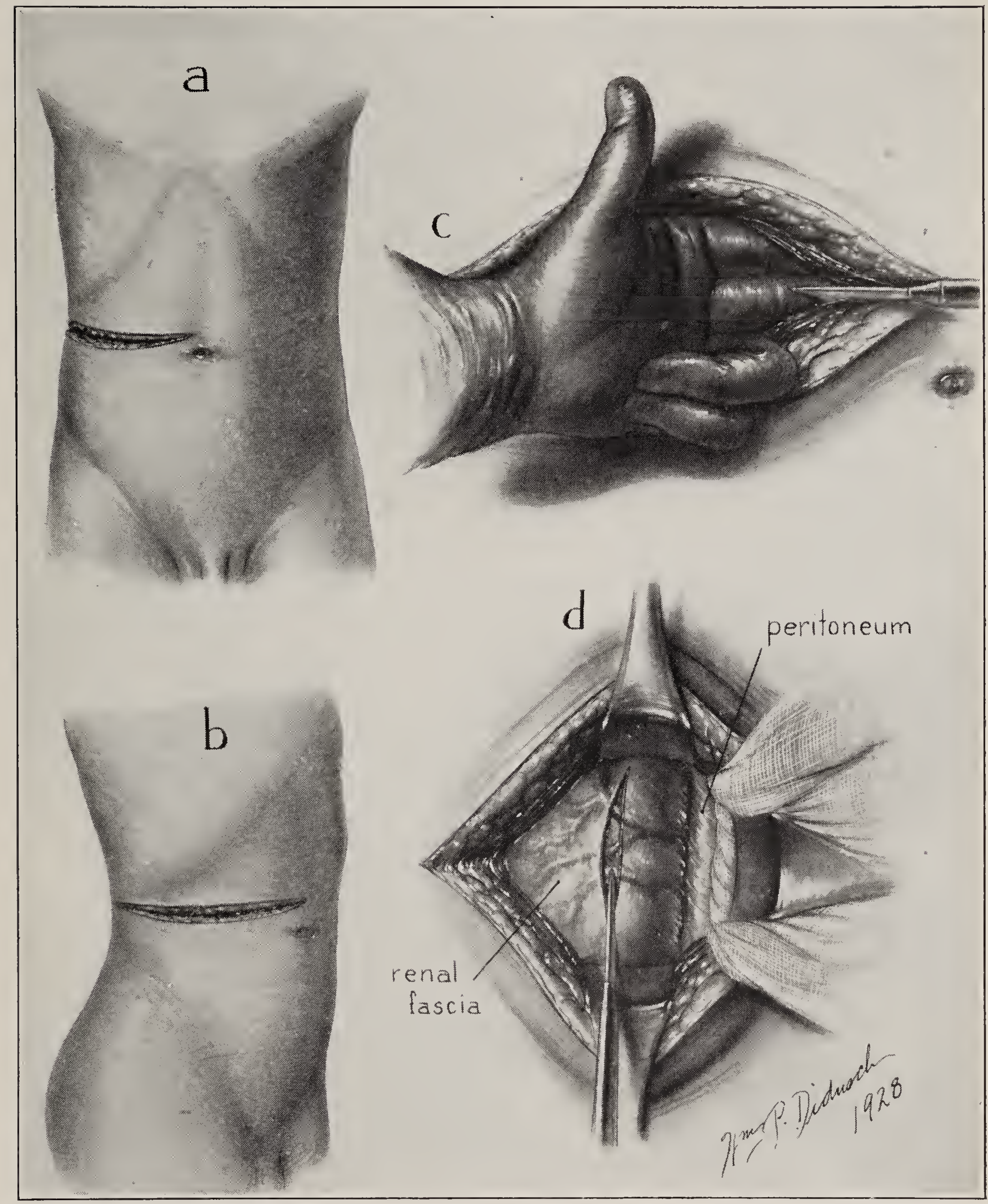


Fig. XXIII. Transperitoneal nephrectomy. (*a*) Skin incision; anterior view. (*b*) Skin incision; lateral view. (*c*) Cutting through the abdominal wall; all muscles being divided at once. (*d*) Incision of renal fascia — peritoneum and contents are drawn toward median line.

Some years ago Quinby called attention to the advantages offered by the transperitoneal approach when it is necessary to give first attention to the large blood vessels of the pedicle. When reached from this side the surgeon's attack may be first made upon the pedicle, while through the lumbar approach much previous dissection is necessary in order to reach it. If it is the pedicle of the right kidney which is to be investigated, it is accessible after mobilization of the duodenum, as in the procedure for pyloroplasty. When the left pedicle is sought, an incision can be made in the parietal peritoneum where the jejunum begins, left of Treitz's ligament. In handling malignant tumors, or possibly tuberculosis, this method of approach prevents dissemination of infection through the blood vessels — a very important consideration.

NEPHROPEXY

The entire subject of mobility or ptosis of the kidney has undergone many phases since renal surgery had its inception. That the kidney may become abnormally mobile was probably known to the ancients. It was certainly realized for a long time before it was suggested that it might be surgically fixed, or some other means employed to return and maintain it in its normal location. There is reason to believe that the condition may be either congenital or acquired. Probably most of the acquired cases occur in subjects who have some slight congenital variation which makes it easier for the kidney to slip out of place. Trauma, loss of perirenal fat, ptosis of organs other than the kidney, or general visceroptosis may account for the greater part of the acquired cases. Women are affected much more often than men. The proportion is given by some authors as forty to one, and 80 per cent. of female cases would certainly be a conservative figure. The condition is most likely to give trouble and in consequence come under observation between the twentieth and thirty-fifth years.

Symptoms and diagnosis of movable kidney. Digestive disturbances and neurasthenia are often the main symptoms of abnormal renal motility. The manifestations are likely to be indefinite, and of gradually increasing severity — often extending over a long period of time. Even when the patient is able to date the onset very definitely to some traumatic accident, or other probable cause, we can by no means be certain that the condition did not exist previously, and was simply accentuated by circumstances which would have had no effect whatever upon a perfectly normal kidney. If the shifting of the renal organ's position causes a kink in the ureter, we will have all the symptoms attending ureteral obstruction. A persistence of ureteral obstruction, more or less intermittent, will lead later on to hydronephrosis, with its attendant symptoms.

The typical "attack" suffered by those afflicted with mobile kidneys — Dietl's crisis — has all the features of ureteral obstruction, and might equally well be caused by the lodgment of a stone, the tightening down of a stricture and so on. The acute pain which is a characteristic feature

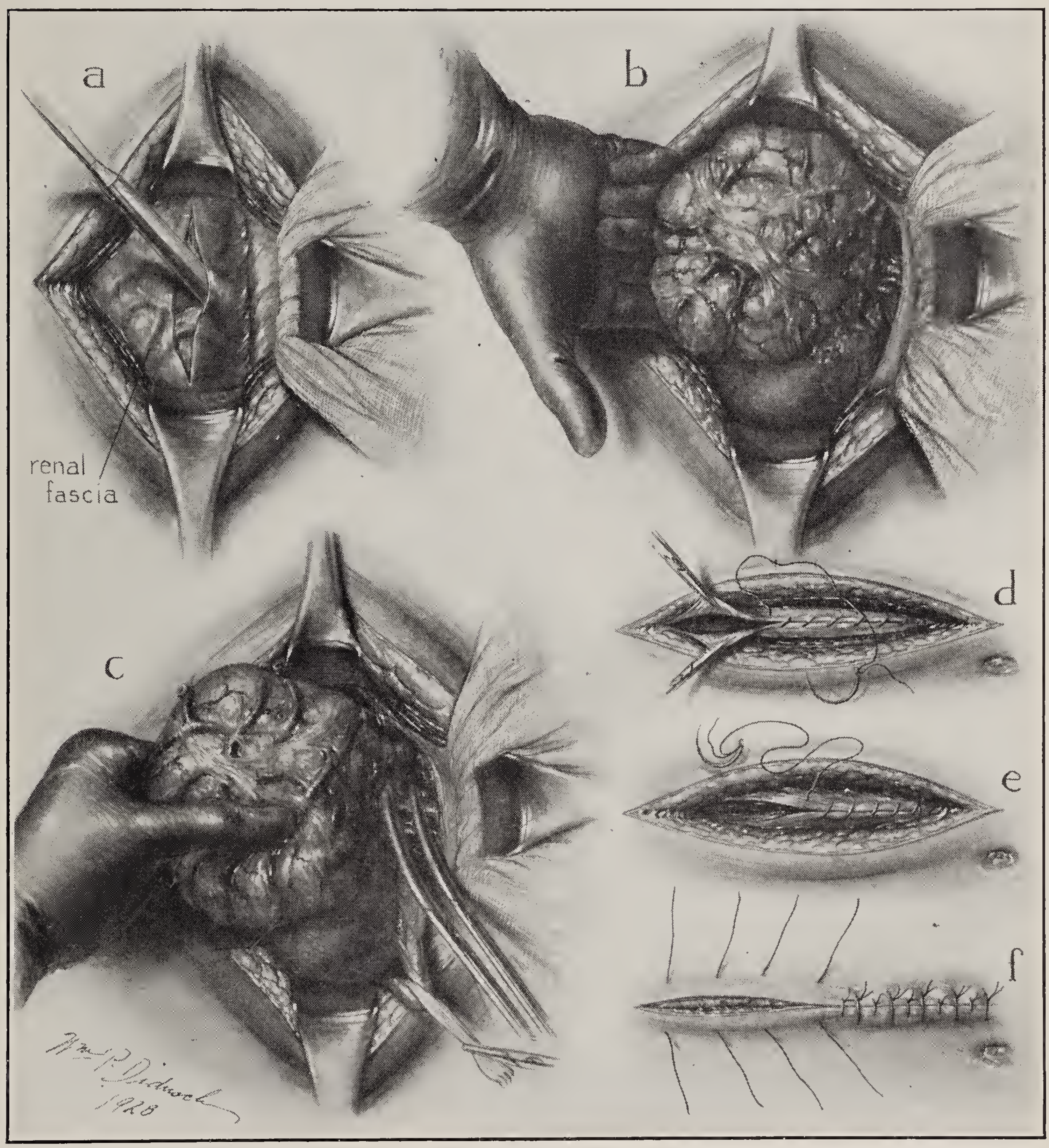


FIG. XXIV. Transperitoneal nephrectomy. (*a*) Stripping off renal fascia by blunt dissection. (*b*) Freeing kidney — tumor exposed. (*c*) Pedicle double-clamped and ligature placed. (*d*) Suture of abdominal fascia. (*e*) Muscles brought together. (*f*) Skin suture completed.

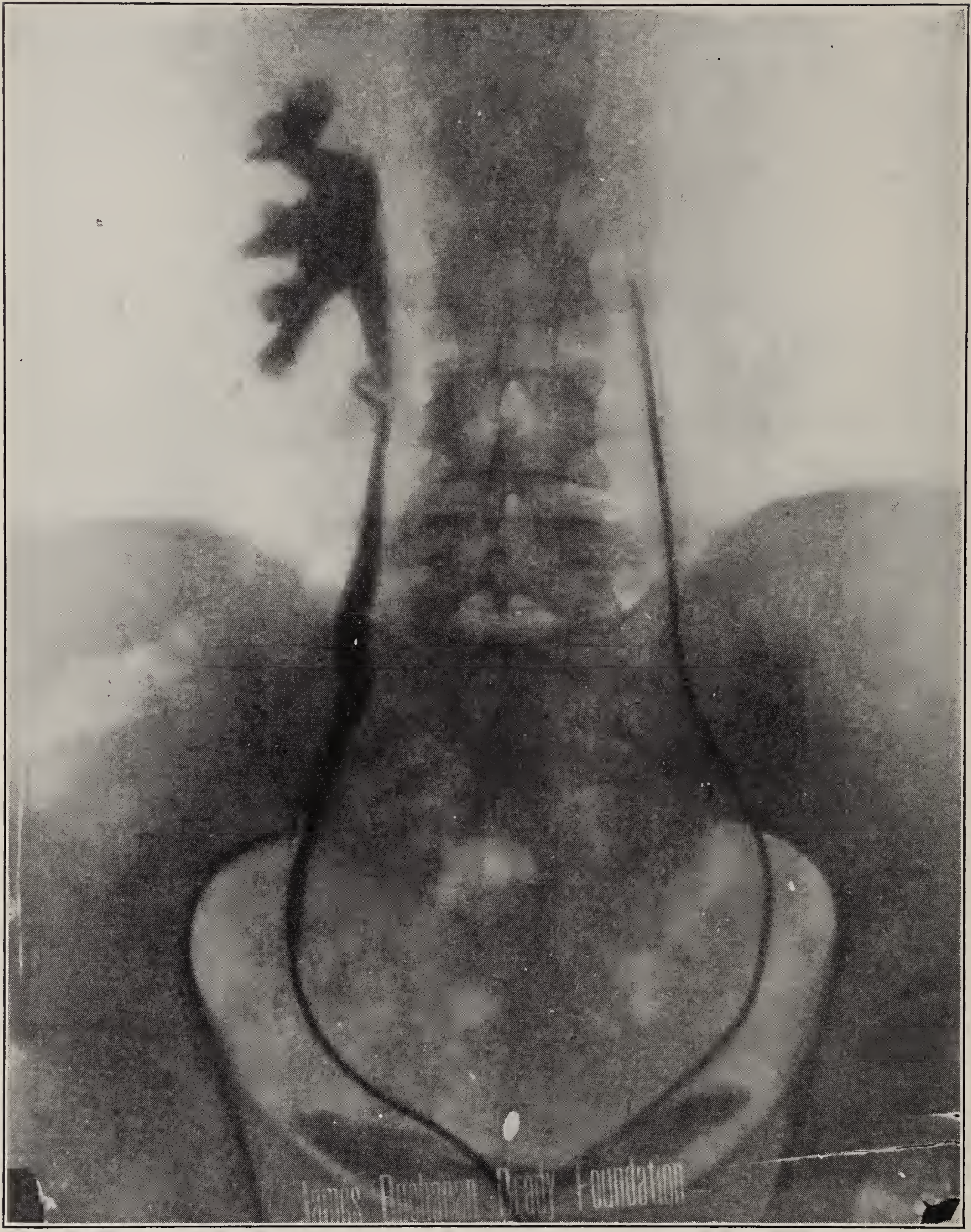


FIG. XXV. Ureteral kink due to movable kidney. Patient previously operated for appendicitis; right-sided pain still persisted. In the supine position, no kink visible; when patient stood erect it appeared in pyelogram. This emphasizes the importance of taking ureterograms in more than one position. A properly fitting belt relieved the pain without resort to operation.

of these crises may be due to ureteral obstruction which was previously only partial, suddenly becoming complete. Compression by an aberrant vessel which takes place when the kidney descends further than it normally should, is a very frequent factor in producing the excruciating pain. Torsion of the kidney pedicle with consequent compression of the normal renal vessels may also have this effect.

The gastro-intestinal symptoms are practically identical with those we are accustomed to associate with appendicitis, and there is no doubt that many an innocent appendix has been removed because of the symptoms which were actually produced by a neighboring kidney. On the other hand there have been periods in surgical history when movable kidney was held accountable for many manifestations for which such other organs as appendix or gall-bladder were responsible. In any event, the symptoms of movable kidney are not sufficiently distinctive to permit diagnosis to be routinely made.

The Roentgen ray has been of great aid to the diagnostician in establishing the existence of movable kidney. Pyelography has proved particularly valuable, and it now seems that Iopax may give still further impetus to roentgenologic diagnosis of the condition. Ureteral kinks will be "splinted" by the insertion of the catheter, and it is important that exposures be made in both standing and recumbent positions. When the patient is standing, the catheter should be withdrawn below the point where the kidney receives support from peritoneum and fascia. Angulation usually happens where the ureteral has less support, which is at its upper extremity. Withdrawal of the catheter lets it take the position into which it is forced by the downward excursions of the kidney, and the kink or twist will be visible in the X-ray film. When Iopax is used this difficulty is obviated.

Palpation is the oldest method of examination, and still remains the most reliable means of detecting renal mobility. All the other methods should be looked upon as confirmation of the findings of the physical examination. In obese patients this may be rather difficult, but should never be omitted or carelessly carried out.

Non-surgical treatment. The psychic disturbances which so very often accompany mobility of the kidney can be explained — at least in part — by the nervous strain of long-continued endurance of pain, and the disturbance of the normal processes of digestion and elimination which ptosis of the abdominal viscera is almost certain to induce. Non-operative treatment of movable kidney means general attention to the patient's physical condition, so that attention cannot be confined to the affected organ alone. Rest in bed will serve to keep the wandering organ in place,

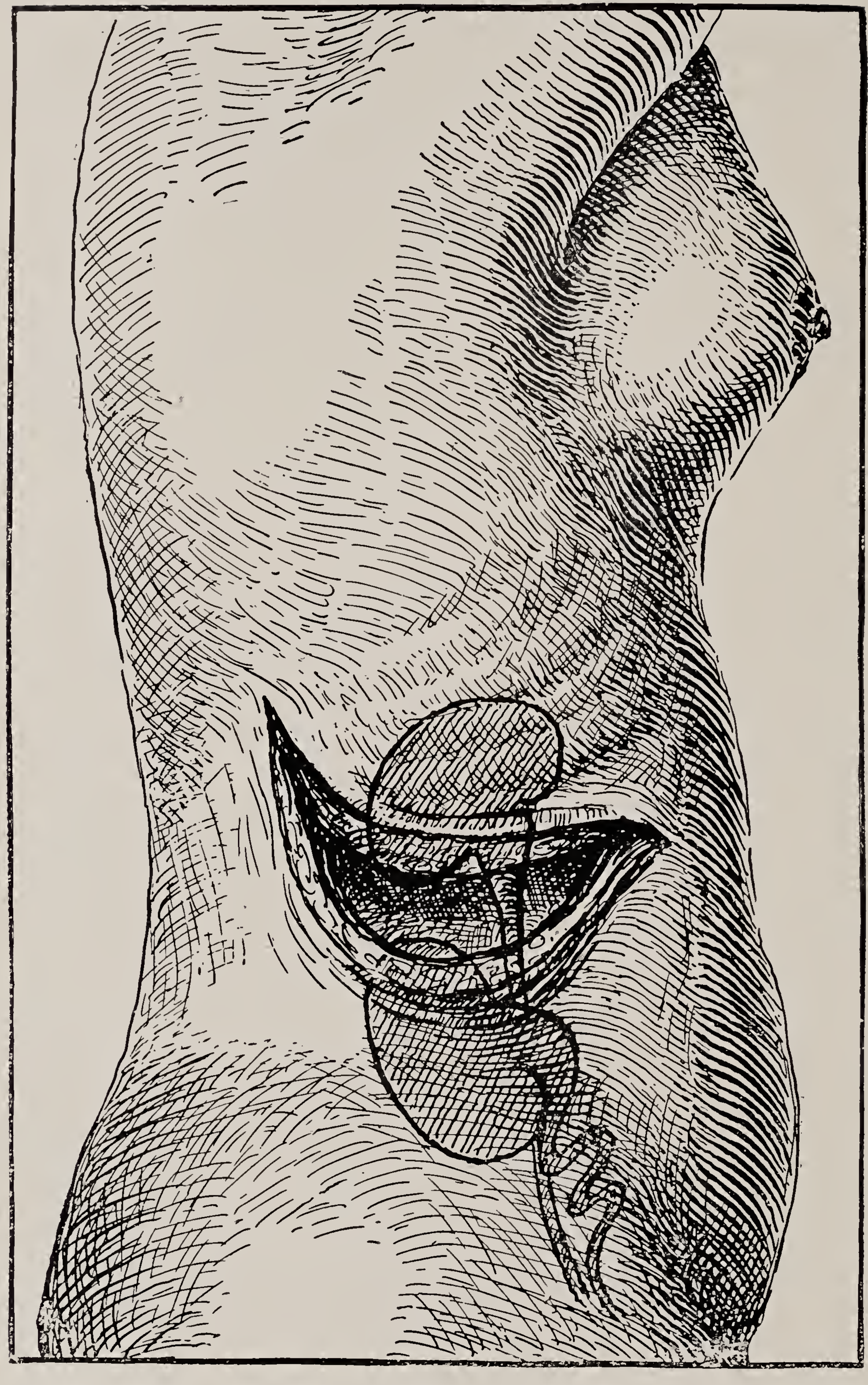


Fig. XXVI. Deming's procedure. Schematic drawing showing position of kidney before and after operation.

especially if the foot of the bed be elevated so that the ptosed viscera will have no tendency toward prolapse. Forced feeding with the idea of reinforcing the perirenal fat, is also serviceable in conjunction with physical inactivity. A properly adjusted belt has helped many of my patients, although in some quarters there has been loud outcry that belts are worse than useless, and only postpone the evil day when surgical fixation becomes inevitable.

Operative treatment of movable kidney. A truly formidable array of operative procedures have been designed and carried out for the relief of movable kidney. This suggests that no one of them has proved entirely satisfactory. The Fullerton operation, now used very generally in England provides a suspension flap for the kidney. This is made by raising a tongue-shaped piece from the capsule on the concave side, passing this flap through the external arcuate ligament, placing the kidney in its normal position and securing it there by stitching the flap to the capsule below. Additional temporary support is sometimes furnished by passing two stitches through the lower part of the capsule so as to form a U. The ends of these sutures are brought outside and tied as a final step in the procedure. At the end of twenty days these stitches are withdrawn.

At the James Buchanan Brady Foundation, New York Hospital, a rather large incision is made, so that the upper five centimeters of the ureter are likewise exposed. A search is made for anomalous vessels and these — if present — are carefully ligated, and then divided, the same treatment being meted out to any adhesions which may chance to be present. Any fat intervening between the posterior abdominal wall and the fibrous capsule is removed. The kidney is suspended by three stitches of catgut (absorbable in 30 days) or silk, set in the posterior surface of the kidney. This is Broedel's triangular suture. One suture is placed above the twelfth rib, and two others set in the quadratus lumborum. Care must be taken not to damage the first lumbar nerve during this maneuver. When the kidney is in position the pre-renal and retro-renal fasciæ below the lower pole of the kidney are drawn together. This fills up the channel down which the kidney has been in the habit of descending, and makes a pocket for its reception. Sometimes this pocket is also attached by suture to the quadratus lumborum and the adjacent peritoneum, though this is not a regular part of the procedure. The fatty capsule is pulled taut, and adhesions favored by splitting the fatty capsule also, and suturing it into the wound. This gives still further anchorage and support to the relocated kidney.

Deming's procedure. Recently Clyde Leroy Deming of New Haven has presented a modified procedure which meets the needs of the majority of cases more perfectly than anything which has heretofore been suggested to me. The incision is begun high in the costovertebral angle and is brought down transversely across, half way between the lower rib and the crest of the ilium. Through the triangle of Petit the fatty capsule is opened postero-laterally, the perirenal fat is stripped off the exposed kidney, and the organ itself, with the intact pedicle — vessels and ureter — lifted into the wound. In exposing the kidney care must be taken to push the 12th thoracic nerve downward when dividing the transversalis muscle, leaving enough margin to insure the nerve's not being included in the suture which closes the wound. Adhesion from both poles of the

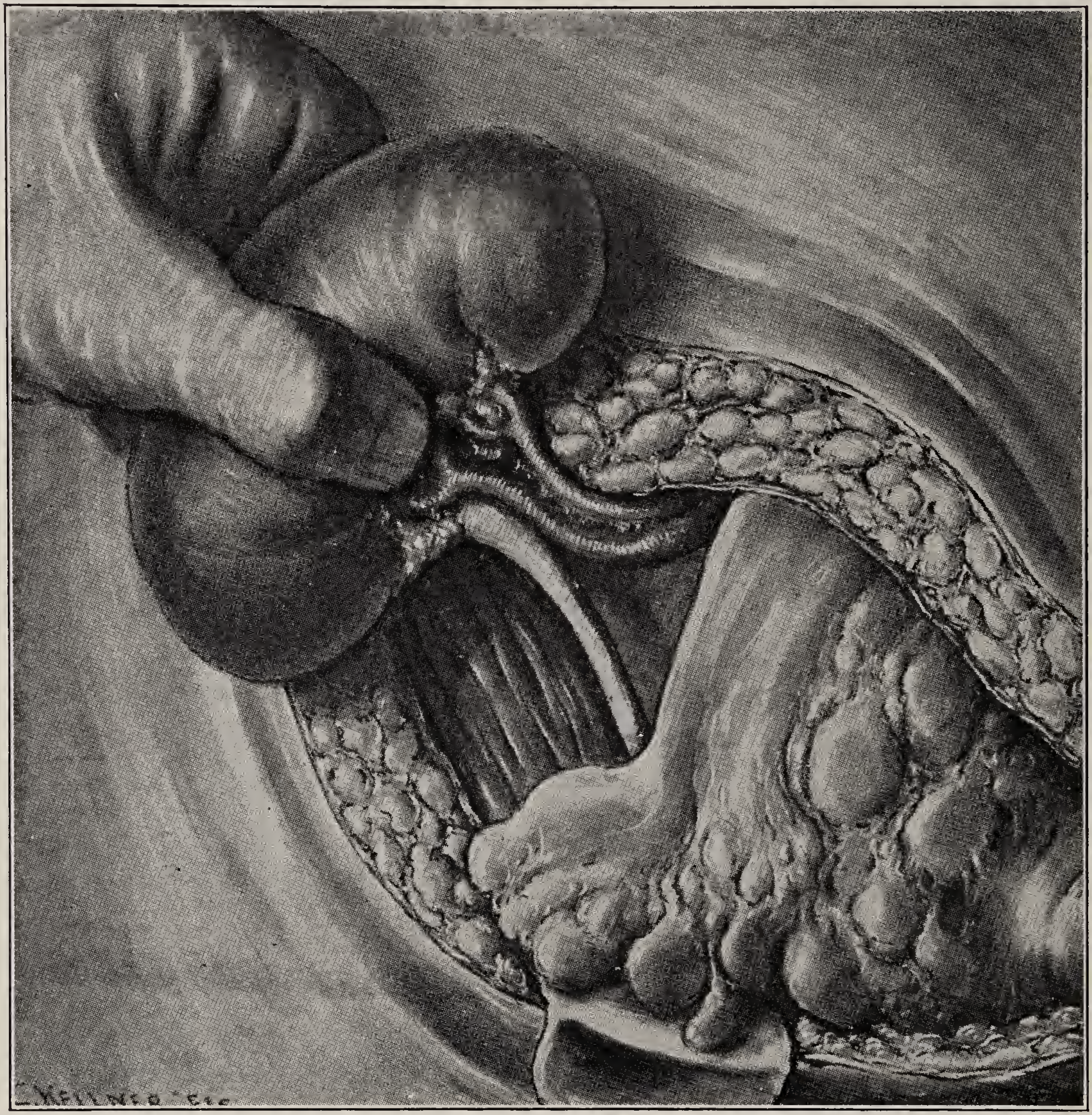


FIG. XXVII. Drawing showing long kidney pedicle when completely dissected free. Deming's procedure.

kidney must be carefully released, and the ureter freed if twisted or kinked. The depth of the renal fossa should be carefully noted. Inserting the hand under the right lobe of the liver the kidney can be placed in a practically intrathoracic position, with the lower pole lying opposite the last rib. The upper pole should be medially placed and the lower pole pointed outward, so as to provide the lower calyx with dependent drainage.

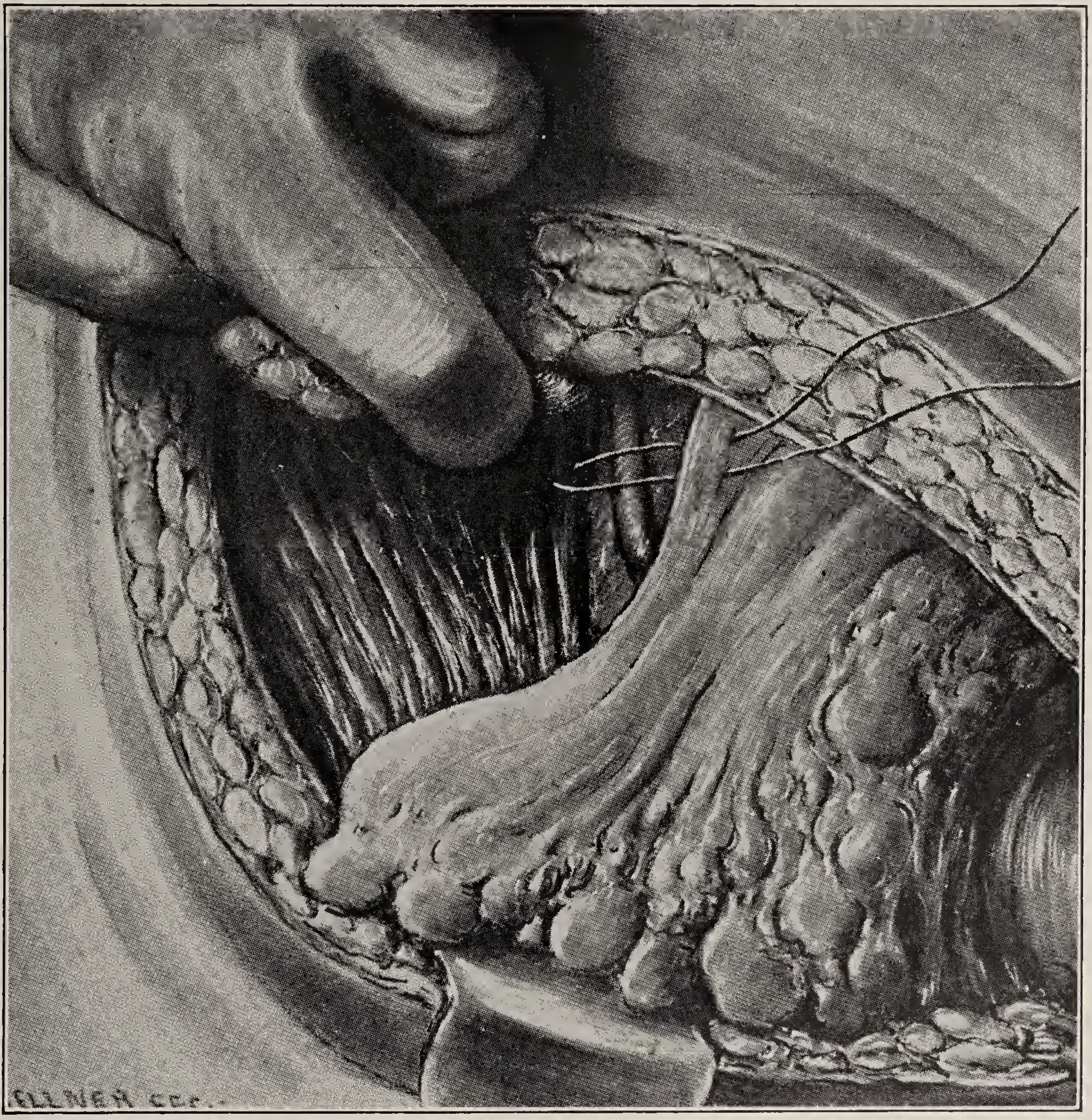
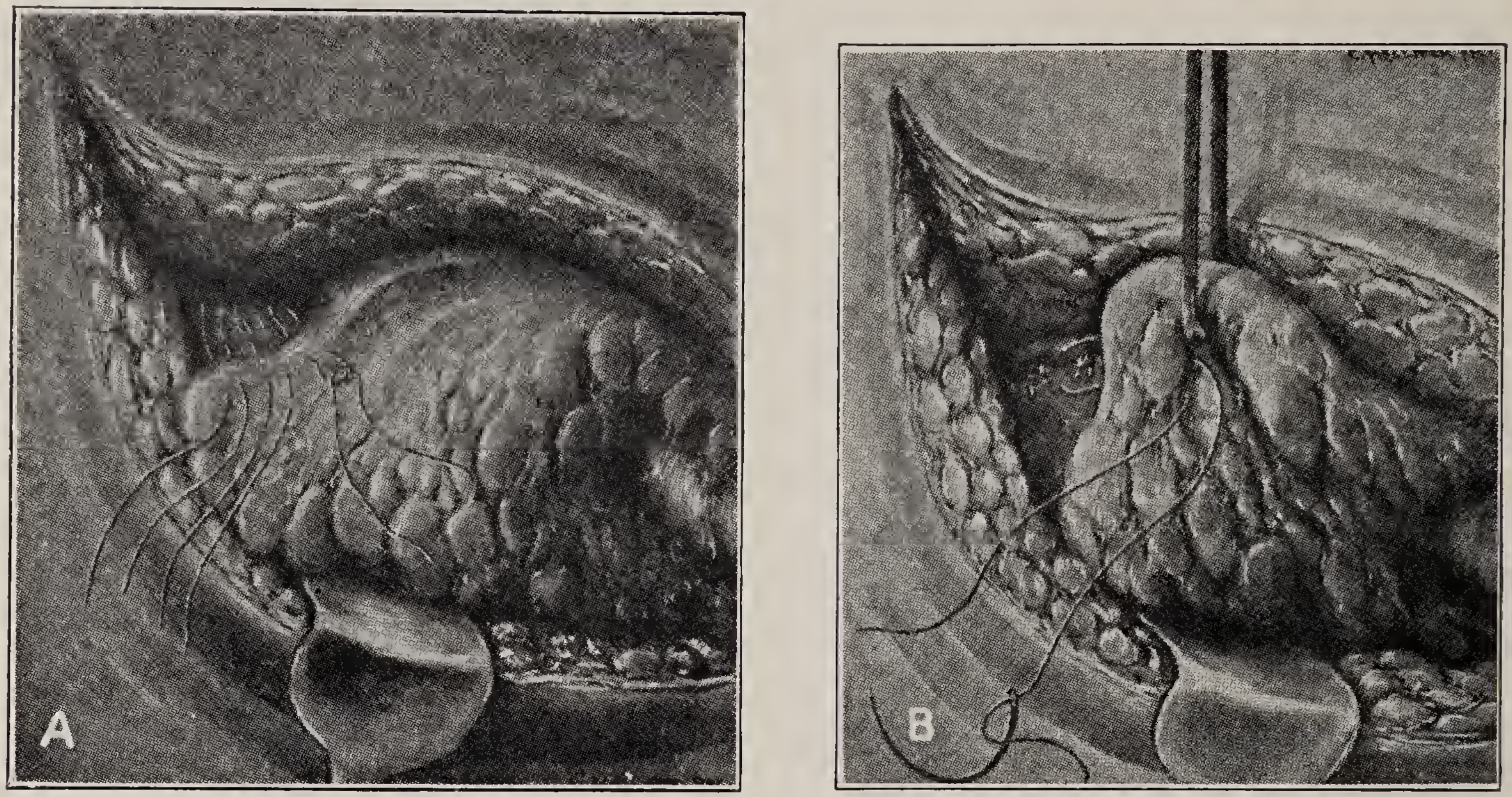


Fig. XXVIII. Drawing showing kidney in position and first stitch passed through perirenal fascia and quadratus muscle. Deming's procedure.

The relocated kidney is secured in this position by a series of interrupted mattress sutures of chromic catgut, No. 00, placed through the perirenal fascia and peritoneum into the quadratus muscle. The perirenal fascia will be sufficiently redundant to permit its easy approximation. The first stitch is about 1 cm. from the ureter posteriorly upon the quadratus muscle, as high up as it is possible to place it. From five to eight stitches will be required to close the aperture. The extraperitoneal fat is brought up and sutured to the sling thus formed, which reinforces the original support, and fills up the space into which the kidney was formerly wont to slip. Care must be exercised not to injure the adjacent bowel during this procedure, and all nerves must be excluded from inclosure with the sutures. The wound is closed in layers with No. 2 plain catgut for the subcutaneous tissues, and interrupted silk sutures for the skin. No drainage is used.



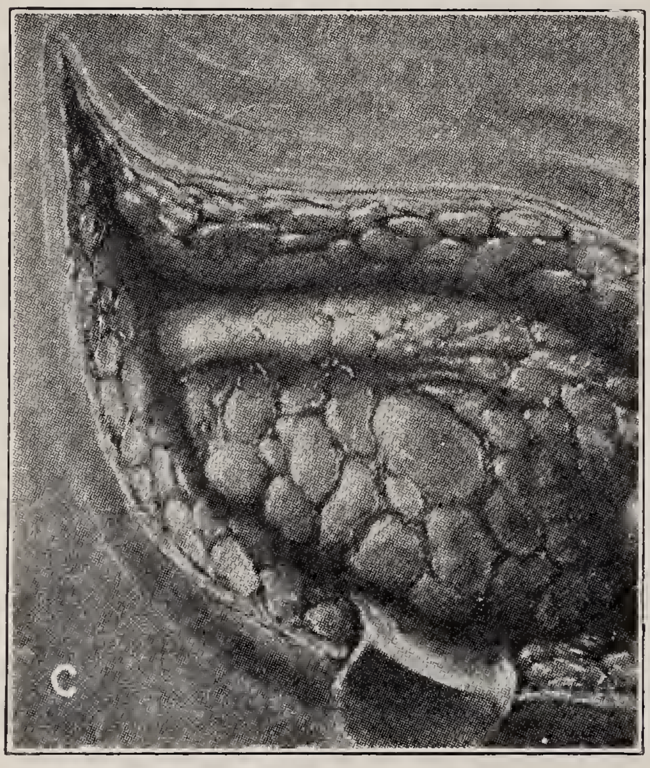


Fig. XXIX. Deming's procedure. (*a*) Placing the first row of sutures. (*b*) Extraperitoneal fat being pulled up and sutured. (*c*) Completion of second row of sutures. (N. B. Figures XXVI to XXIX are used by kind permission of Dr. Deming and of the *Journal of the American Medical Association* wherein they were first published.)

NEPHROTOMY

Any incision of the kidney substance is termed nephrotomy, though intervention upon the pelvis alone is properly *pyelotomy*, which will be considered by itself later on. The procedures which are known under separate designations as *nephrostomy* and *nephrotresis* are actually but special kinds of nephrotomies. The first signifies the establishment of a renal fistula for the drainage of a chronic hydronephrosis or pyonephrosis. If this artificial drainage of the kidney has to be made permanent, as in irremediable obstruction or destruction of the ureter, it is termed nephrotresis. It has been accomplished on but a few occasions and needs no special description. *Resection of the kidney* is done but rarely, and in most of the instances where it was apparently successful, complete removal of the affected organ became necessary later on. Richter of Chicago recently reported a successful case, and another was published from the clinic of H. H. Young some ten years ago. In both of these a section of diseased kidney tissue containing stones was removed, leaving sound functionating tissue intact. If the opposite kidney is missing or functionless, nephrotomy by resection may be the patient's only hope of life.

Drainage of hydronephrosis. A form of nephrotomy which should have special mention is operation upon the kidney for relief of hydronephrosis. As the object here is the establishment of drainage, the incision should be made through the kidney's outer wall, as low down as possible. In most subjects the kidney will be so distended that there will be no difficulty in entering it, and a generous incision should always be made, so as to admit a large drainage tube. It is a good practice to form an artificial fistula by suturing the cut edges of renal tissue directly to the lumbar incision which, in cases of infected hydronephrosis, gives adequate drainage of pus and retained urine. Such a fistula should heal spontaneously after a few weeks, but it is sometimes difficult to obtain closure, the urine continuing to discharge through the surgical opening. The insertion of an indwelling catheter will often serve to divert the flow of urine, and as a general rule, with the urine out of the way the fistula will heal quickly. Should healing fail even after this expedient has been practiced, it will be necessary to make another exploration of the kidney to determine the origin of the continued infection, unless, of course, this is already recognized.

Tuberculous cases should not be treated by nephrotomy if any other way is permissible. Nephrectomy is more satisfactory than a long-continued struggle to preserve a badly damaged renal organ. Naturally the decision depends upon the conditions on the opposite side. When the infection is bilateral the surgeon must content himself by employing whatever palliative measures seem best suited to the particular case in hand. Ureteral stricture is so common a finding in tuberculosis, and hydronephrosis because of such a stricture so frequently follows, that attention to the ureter will often serve to alleviate, or even cure com-

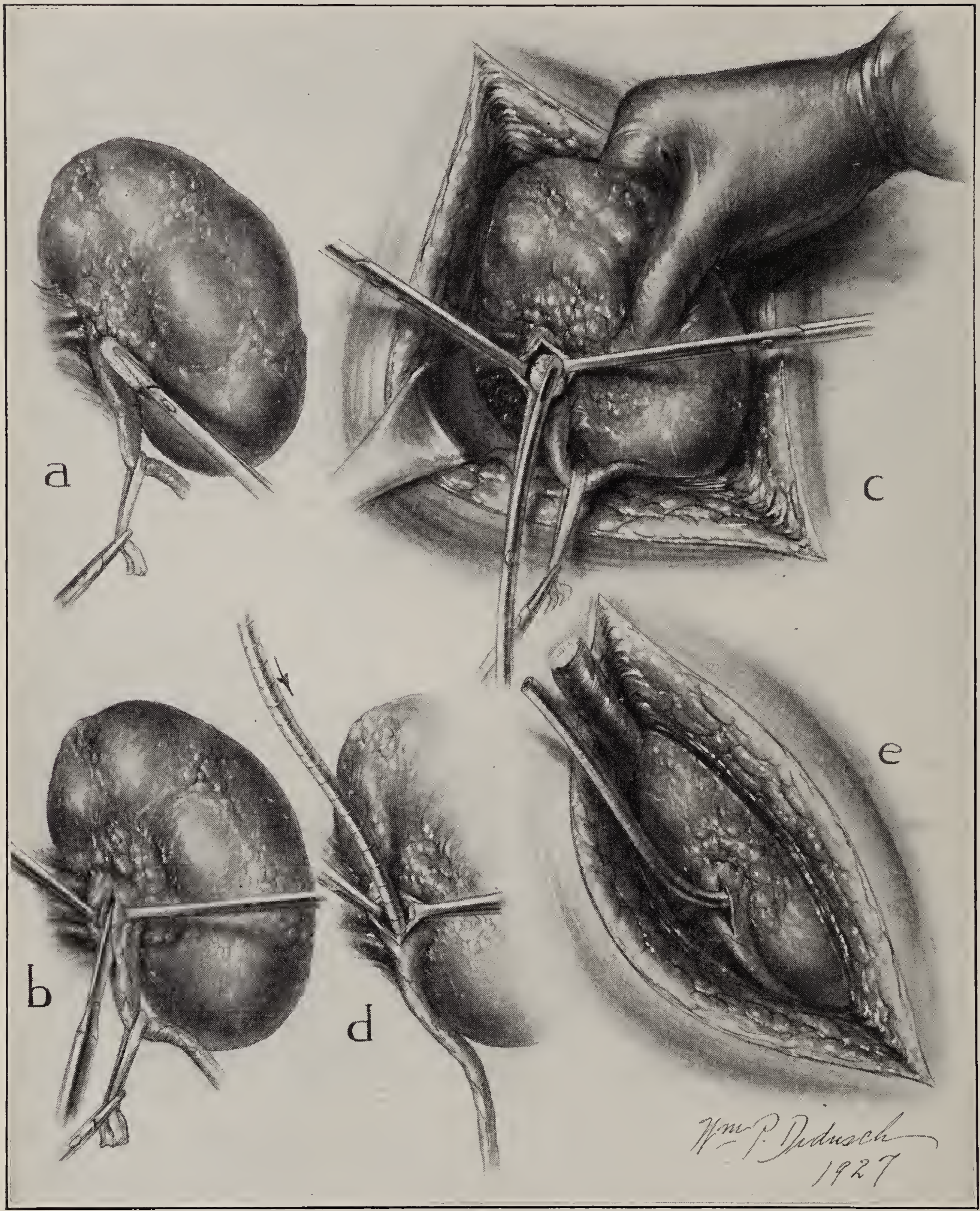


Fig. XXX. Pyelotomy, "Simple", first degree, for small stones. (*a*) Kidney exposed — ureter freed — fat being removed from pelvis. (*b*) Incising renal pelvis, (*c*) Stones removed by means of forceps. (*d*) Passing graduated probe down ureter to remove obstruction and dilate the lumen. (*e*) Final closure — with drain in place.

pletely, the condition existing in the kidney. If it is possible to dilate such a stricture adequately, direct intervention upon the kidney itself may be entirely avoided, free drainage being established by the natural route.

Control of hemorrhage. In nephrotomy of any type the control of hemorrhage is perhaps the most important feature. As the majority of these operations are done for the removal of stone, and it is important that all calculi should be extracted at a single intervention, the search for small fragments may mean an extensive loss of blood. The kidney pedicle may be clamped, but digital pressure is better if it can master the situation, as the damage to the walls of the great vessels is so much less. Ligature by an elastic band, though occasionally recommended and practiced, has in my opinion, no place in hemostasis of the renal pedicle. Some prominent operators report safe compression by the application of special rubber-jawed clamps, or those well padded with gauze. In any event, no compression should ever be brought to bear upon the ureter, which must be carefully differentiated from the blood-vessels.

Manual compression. The method which I have found most satisfactory is to have an assistant place both hands, palms upward, beneath the mobilized kidney. The pedicle can thus be compressed between the index and middle fingers of each hand, the thumbs pressing upon their respective index fingers for reinforcement. Some assistants find it more satisfactory to put only the left index and middle fingers on each side of the pedicle, using the thumb and forefinger of the other hand to compress the ends of the fingers about the pedicle. If the pedicle is short and the kidney a large one, the method advocated by Papin can be advantageously applied. According to whether operation is to be done on the right or left side of the kidney, the assistant slips the tips of the right or left fingers down beside the kidney, so that they push the pedicle back against the psoas muscle, which, backed by the adjacent lumbar vertebræ, offers firm surface against which compression can be made. For a brief procedure the hemostasis thus secured will usually be found adequate.

Operative fluoroscopy. Of inestimable value in locating small stones liable to be overlooked is fluoroscopy during operation for calculus. This is now used extensively whenever possible. If the Roentgen work is well done and the pictures presented are properly interpreted, the operator will know in advance exactly where to incise the cortex after the kidney has been exposed. Thus no unnecessary cutting will be done. This ideal is practically never reached but much progress has been made in the past few years and each surgeon can contribute his share to promote more scientific exactness in the diagnosis of renal calculus and its subsequent removal.

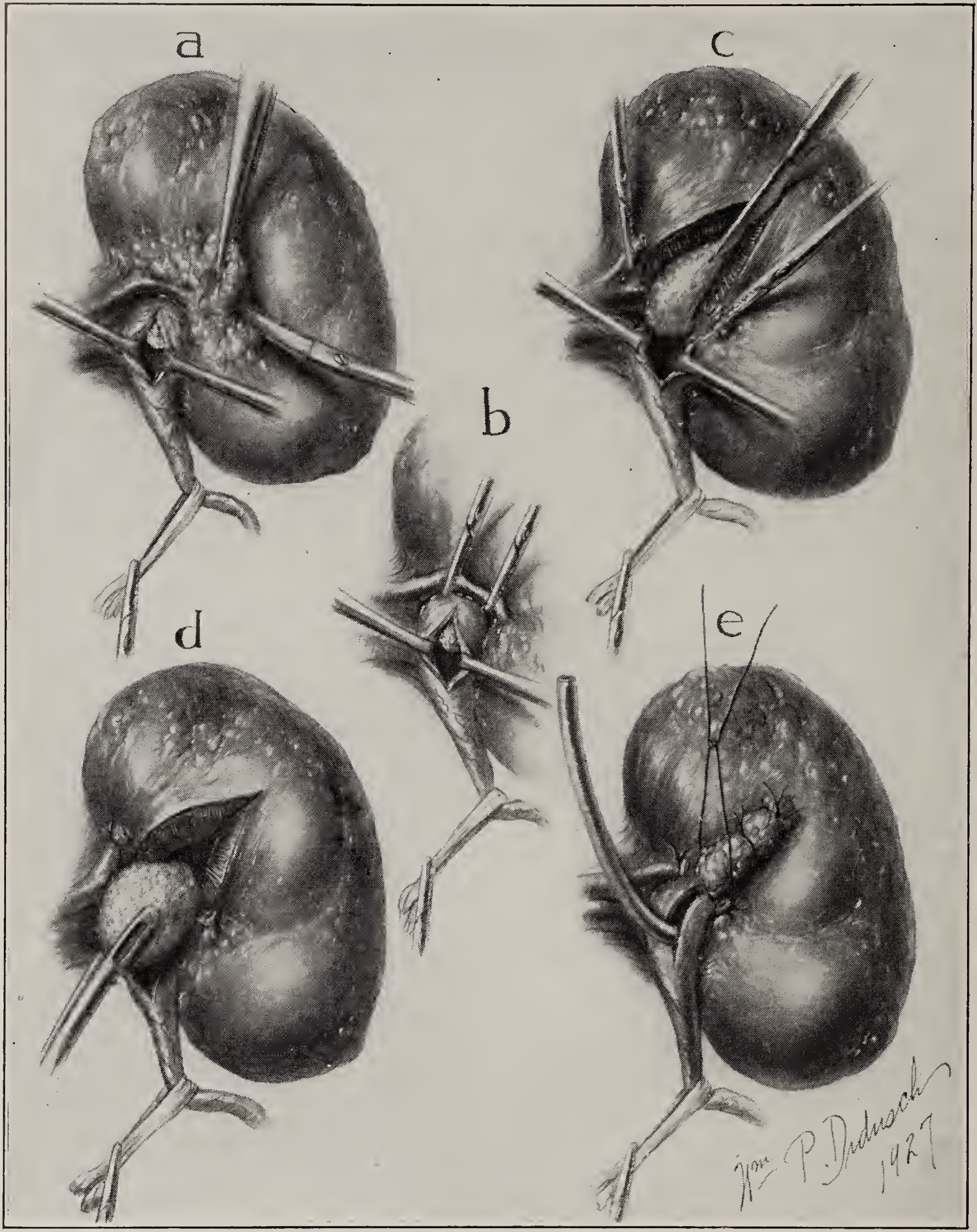


FIG. XXXI. Pyelotomy, second degree (for cases where stone is too large to be removed through first degree incision). (*a*) Kidney exposed — fat removed from pelvis — exposing posterior branch of renal artery (*b*) Clamping posterior branch of renal artery before division. (*c*) Extending simple pyelotomy incision into cortical substance of kidney. (*d*) Removal of stone. (*e*) Closure of drain in pelvis.

Incision of kidney tissue. If a stone cannot be exactly located beforehand a general incision must be made, usually along the axis of the kidney, but carefully avoiding interference with the large vessels. The length and depth of the incision depends upon the amount of information the surgeon may have been able to obtain. Tumors and cysts are often visible on the surface so that the exact spot where work should be begun will not be difficult to select. No definite rules can be laid down. The nephrotomy opening may vary all the way from a slight nick in the kidney tissue to complete bisection of the entire organ. The employment of silver wire instead of a knife when it is necessary to bisect the kidney was suggested some years ago by Cullen and his associates. This appears to bring less bleeding in its train than does the scalpel. The kidney is not completely cut in two, the section being begun on its convex edge and carried down to within a short distance of the lower edge, leaving enough tissue to form a " hinge."

In general, the operator should make all incisions in areas of least vascularity, as for example, the junction of the upper and middle third, or of the lower and middle third. From this point the incision should be carried in a straight line toward the renal pelvis. If the kidney is to be split with the knife, it will draw less blood and be found easier to insert the knife and then bring it from within outward, rather than to " cut into " the kidney. When the cutting is to be done with silver wire, this wire is best carried in upon a needle and then permitted to cut its way out by gently " sawing " it backward and forward, applying light but steady traction upward. Coming in this direction — from within outward — either knife or wire will push its way between the blood vessels encountered, rather than cutting through them, as occurs when the section is made from above downward.

Pyelotomy. When the calculus formation is confined to the renal pelvis, and there is no reason to suppose the kidney proper to be otherwise than normal — or at least not so abnormal as to need extensive exploration — the pelvis alone is incised. Some stones in the kidney substance can best be removed by opening up the pelvis and in some instances, by inducing renal colic, stones in the kidney have been forced into the pelvis, whence they are easily lifted out through a simple pyelotomy incision.

The incision is made at the junction of the ureter, over the stone if possible. If this incision be made long enough to reach to the hilus, there is likely to be profuse hemorrhage. Care should be taken to avoid this. It will be seen that this incision of the pelvis gives but little room for exploration. A probe may be passed through it into the ureter but there

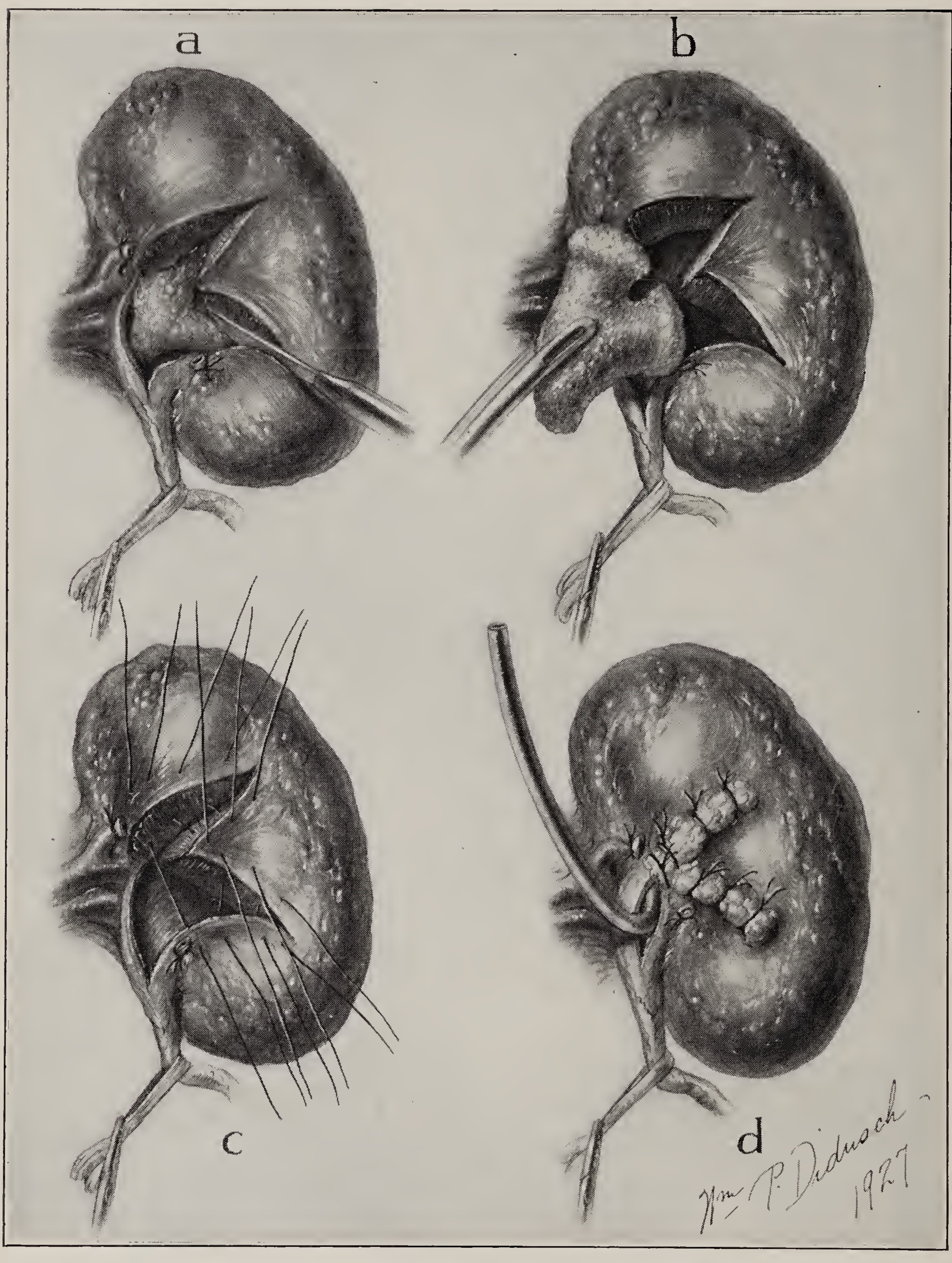


Fig. XXXII. Pyelotomy, third degree; used when calculus is branched, or too large to remove by second degree method. (*a*) Extending simple pyelotomy incision into cortex. (*b*) Incision completed — stone being removed. (*c*) Method of placing sutures. (*d*) Final suture with drain in pelvis.

is no access to the kidney itself and even the calyces can hardly be attained. But such an incision is very easily closed and unless infection be present it may even be left unsutured. It is much safer to set in a stitch or two to guard against urinary leakage. In cases where leakage is especially feared a flap of adjacent renal capsule is brought down to cover and reinforce the line of suture after it is completed.

Closing a bisected kidney. The closure of a bisected kidney is naturally a much more extensive undertaking than is that of a small pelvic incision. If the renal substance has not been very deeply incised, one or two tiers of mattress sutures may be enough to insure firm union. If bisection has been done these mattress sutures are set in one above another, and a similar technique is used for traumatic rupture, when this is susceptible of such repair. The capsule may be closed with continuous stitches, though if the incision be a short one, interrupted sutures may do as well. The interrupted stitch is not suitable for the deeper tissues as it is liable to cut through them. On the more resistent cortex this accident is not likely to happen.

Excision and drainage of abscess. Another form of nephrotomy frequently employed is incision for evacuation of abscess, or circumscribed suppurative nephritis. When the kidney has been exposed and brought up into the wound, the site of the pus collection will usually be visible at once. If not, the pedicle must be clamped or compressed, and an exploratory incision made through the renal cortex, usually in the lower third, following along the line of greatest convexity, a scant half-inch below the midline. The knife should be passed deeply enough to enter the calyces. This opening may now be enlarged by the introduction and opening of a blunt forceps until there is sufficient room for the fingers, by which the surrounding tissues should be carefully palpated. If it becomes necessary to enter the pelvis, the incision will have to be prolonged and this is best done when this portion of the renal organ is distended. Normal saline may be injected into it with a needle, the constriction previously placed upon the pedicle preventing it from flowing out. When the pus is found and evacuated and the cavity cleansed, the wound is closed over a soft rubber drainage tube, the capsule being sutured around it.

Operation for perinephritic abscess. When suppuration beneath the renal capsule has been demonstrated, the surgeon undertaking to evacuate it will usually find that the adipose capsule has already been invaded and in most cases, the fibrous layer as well. Papin stresses the importance of making adequate provision for emptying out the pus collection, but going no further than is absolutely necessary. He advises a lumbar incision of sufficient but not excessive length, which will give immediate access to the pus, if the collection lies in the muscles immediately below. It is not always so easily come upon, unfortunately. Occasionally the abscess will be wholly retro-renal and the surgeon may be obliged to explore some distance, for when the original focus is in this location infiltration of the retro-renal fascia rapidly takes place.

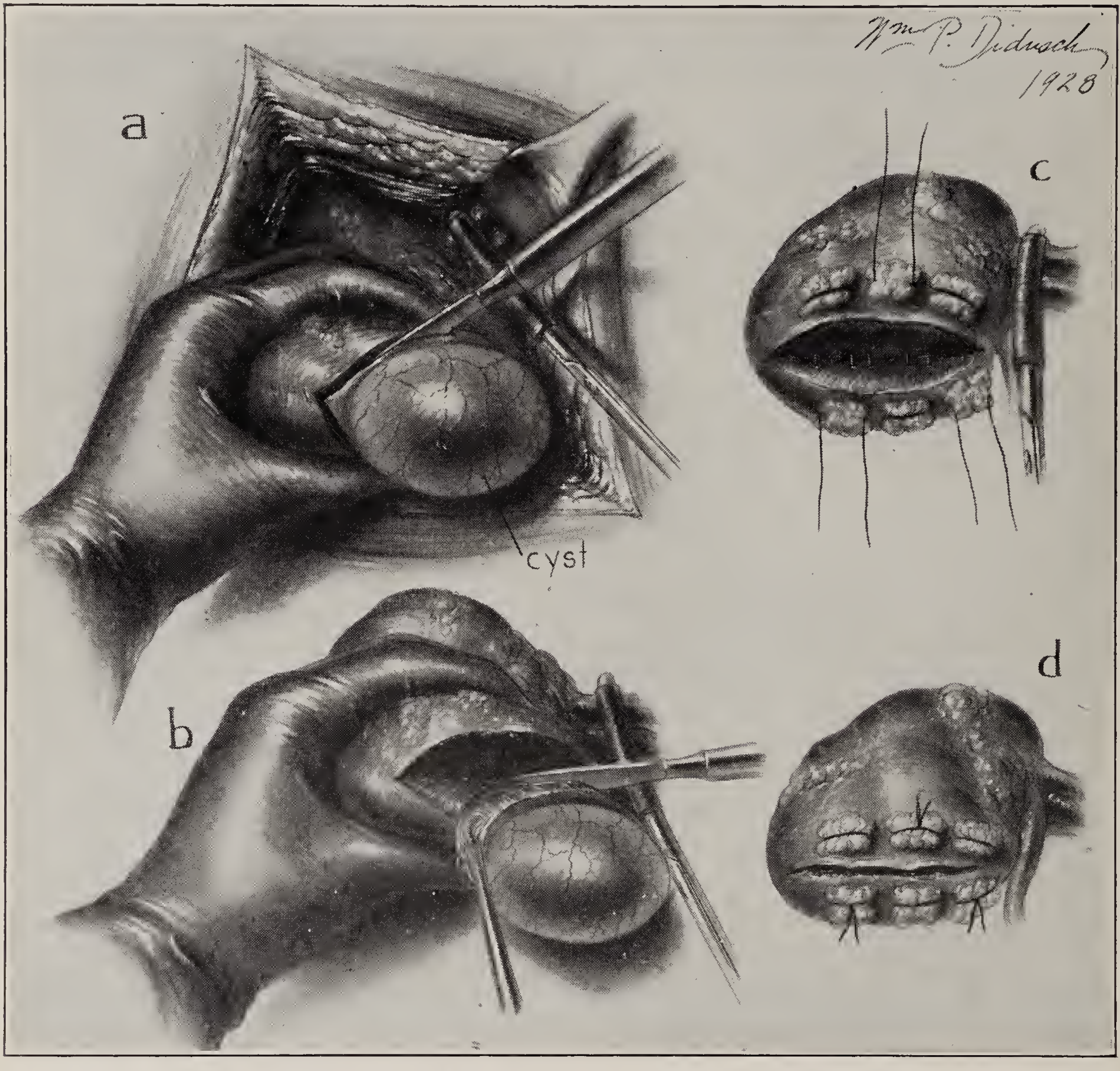


FIG. XXXIII. Method of resecting kidney for solitary cyst or for tumor. (*a*) Pressure made upon pedicle to control hemorrhage by means of rubber-coated clamp; incision carried around cyst. (*b*) Deeper dissection of cyst. (*c*) Method of placing suture for repairs. (*d*) Completed suture — using small pieces of fat to prevent suture from cutting through kidney tissue and for control of hemorrhage.

It is not until the cavity has been emptied that one can make sure just whence the abscess has arisen. When all the pus has been wiped out it is very essential to examine the cavity with care, to be sure no accessory pockets or fistulæ have been overlooked. The establishment of good drainage is, of course, highly essential. Papin recommends as many as three drains, if there seems to be need of them. The dressings should be changed daily for some time, but no flushing of the cavity is to be practiced until drainage has ceased.

Surgery of renal cysts. Large solitary cysts are usually located at one or the other of the poles of the kidney. In some cases it can be mobilized, the parenchyma incised and the entire cyst removed. But often so much renal tissue will have been destroyed that the organ has practically no functional value, and if function on the other side be adequate, nephrectomy will be the wisest procedure. More commonly solitary cysts will have to be punctured, their contents evacuated and the cavity excised, followed by suitable suturing. Some operators cauterize the cavity with phenol or other chemical agent. An equal number hold that this procedure has no justification.

Operative treatment of polycystic kidney. A polycystic kidney should never be removed even if the opposite organ appears to be functionating normally. This condition is almost universally bilateral, and the removal of even so little normal tissue as may remain in a badly encysted kidney, will but add to the burden of the opposite side and hasten a fatal termination. The only aid which the surgeon can give the unfortunate possessor of such a kidney is to expose it and puncture the cysts according to the practice of Rovsing. The kidney is then partially decapsulated and replaced, the incision being closed about a cigarette drain. Some operators do a nephropexy in addition, believing that fixation will lessen the pain which so often accompanies this condition. In some cases enough tissue capable of function will remain in a kidney to permit the patient to live for a number of years. Women have even been able to pass through pregnancy after such an intervention.

NEPHRECTOMY

The removal of one kidney is now considered good surgical practice when the opposite organ can be demonstrated to have functional ability to carry on the work of both sides. Indications are: Chronic hydro- or pyonephrosis which cannot be relieved by removal of its causal factors; primary unilateral tuberculosis; calculus pyonephrosis; malignant tumor; necrotic nephritis, and extensive traumatic injury. To these may be added aneurysm of the renal artery and incurable renal fistula following surgical intervention or injury to the ureter.

Removal of kidney through a lumbar incision. Nephrectomy by the lumbar route in uncomplicated cases is a comparatively simple operation and carried out under paravertebral anesthesia with proper hemostasis gives excellent operative results with little shock to the patient. After exposure in the manner described when considering the various renal operative incisions, the surgeon examines carefully to make certain that the organ has been freed at every point except the hilus, and that where the ureter joins the renal pelvis. It is my own practice to deal with the ureter first, although many surgeons begin by dissecting out and ligating the blood vessels. The ureter is freed by downward stripping and brought up into the wound, which is conveniently accomplished by passing a tape underneath it, as in pyelotomy. Clamps are applied to each side of the proposed line of section, a double ligature placed between the clamps, the ureter cut off at this point and the ends cauterized with pure phenol. The cauterizing agent may be injected into the ureter before the clamps are applied if it seems desirable to sterilize its lumen.

Treatment of the vascular pedicle. The vessels of the pedicle should be carefully dissected out, examined and separately clamped. In some cases three clamps are used. Ligatures are placed at every clamp, the grasp of the instrument being loosened as each ligature is tied so that they can slip into the indentation in the vessel wall made by the clamp. The stump nearest the kidney should be ligated before that on the opposite side. Many operators content themselves with ligating the pedicle as a whole, but while this may appear easier and more expeditious, the double assurance against hemorrhage which this extra care in clamping and ligating gives more than compensates for any excess work or care it may demand. In some cases where there has been a large amount of inflammation the surrounding tissues are in such a state that isolation of each vessel becomes impossible. Under these conditions heavier clamps should be used and the precaution of double ligation observed as in the first instance. The pedicle cut away, a transfixation suture is placed just beneath the clamps and tied upon both sides. All clamps should be removed as soon as the surgeon has assured himself that every danger of hemorrhage has been eliminated. Under no circumstances should clamps be left for later removal, nor should dependence ever be placed upon them to promote adequate hemostasis. The ligatures should be so adjusted as to be adequate for this purpose, and failure to accomplish this is inexcusably poor surgical technique.

In uncomplicated cases the fascia is immediately closed with interrupted catgut sutures, the muscular layer in the same manner, and the skin with an interrupted silkworm gut suture, a cigarette drain being placed at the renal pedicle.

Intracapsular nephrectomy. In cases presenting many adhesions it may be very difficult — or altogether impossible — to strip the fatty capsule from the renal capsule proper. Under these circumstances it may be necessary to incise the renal capsule and peel it back, as in decapsulation. If possible, the capsule should be loosened all the way to the pedicle so as to expose the vessels in such a way that they may be properly ligated. This is not apt to be easy, for often they are so hidden in fat beneath the reflected capsule that considerable dissection will be required in order to reach them. The kidney is freed by blunt dissection until it can be removed and the resulting cavity should be packed. More extensive drainage is necessary than when the capsule is removed with its kidney. This method is employed only when nothing else is possible, as the difficulties of satisfactory ligation of the pedicle and the poorer exposure necessitated make it decidedly unsatisfactory. The original incision usually has to be lengthened in order to permit better exposure, so that excision of a portion of the twelfth rib may very likely be necessary. The handling of a kidney surrounded by dense adhesions and often structurally weakened by the existence of cavities, pus pockets and calculi, will present great difficulties even to the most skilful surgeon. Sometimes the kidney can only be removed piecemeal — which is known as *nephrectomy by morcellation*, a procedure to be avoided whenever possible. If the conditions can be foreseen — which, unfortunately, is seldom the case — transperitoneal nephrectomy is a much safer and surer procedure.

Nephro-ureterectomy. Sometimes the kidney and upper ureter are freed through the regular lumbar incision, the pedicle ligated and divided, and the kidney left hanging from the wound with the ureter still attached. The patient's position is then shifted and an anterior rectus incision made, through which the lower portion of the ureter is freed, ligated and cut at its point of entrance to the bladder wall.

Removal of tuberculous kidney. Nephrectomy for tuberculosis requires special precaution to prevent dissemination of the infection. The kidney should be removed intact within its capsule if possible, and the ureter well cauterized to prevent infection from that quarter. Unfortunately, it is in tuberculosis that we are most likely to find the perinephritic tissues badly infiltrated, and to encounter very resistent adhesions. This makes clean enucleation doubly difficult. One well known operator closes the nephrectomy wound without drainage, having first cleansed the cavity and filled it with normal saline solution. Another reaches the tuberculous kidney by an extraperitoneal incision begun low down and curved more than that used for nephrectomy in less infected conditions. He injects the ureter with pure phenol as soon as it can be exposed, doubly ligates it and then proceeds to take out the kidney. No attempt is made to remove the ureter unless it be much dilated — a typical hydroureter — for it is believed that inasmuch as it is impossible to extirpate it entire, the preliminary cauterization with phenol is as good a guarantee against spread of the infection as a partial removal would be. In England it is believed that if it be possible to remove the kidney intact within its fatty capsule, dissemination of tuberculous infection may be avoided, provided no extra-renal focus chances to be torn across. The ureter is burned off with the actual cautery, and primary healing for two out of three cases so treated is claimed. If the wound breaks down and forms a fistula, Beck's bismuth paste has been found a valuable aid in bringing about closure. For extension of the tuberculous process into the bladder diathermy has been found a good curative agent. It must be applied with caution.

TRANSPERITONEAL NEPHRECTOMY

When the kidney is greatly enlarged or tumors are present, or in the presence of large solitary or multiple cysts or hydronephrosis, it may be wiser to expose it by an abdominal approach. A median laparotomy incision is usually employed, the intervening structures pushed out of the way and held in place by hot sterile pads fixed by retractors. The posterior parietal peritoneum is incised over the involved kidney, great care being exercised not to damage the adjacent colon, or interfere in any way with its blood supply. Through this incision the kidney is freed from its fat capsule and the pedicle laid bare and carefully examined. The vessels and ureter are separately clamped, ligated and divided as in lumbar nephrectomy, and the cauterized ureteral stump allowed to drop back into the abdomen. The kidney is gradually freed, all bleeding points being carefully caught up as the dissection proceeds. In the event of a malignant tumor it is usually necessary to remove all the perirenal fat and even more distant tissues, usually including the suprarenal gland. Many surgeons now implant radium emanation in the vacant kidney bed, capillary glass, or better, metal implants being employed. These are left permanently in the tissue.

When there has been an extensive removal of tissue as in the case of a large tumor, the resulting cavity must be adequately drained. This is best accomplished by the insertion of a soft-rubber drainage tube carried through a stab wound in the most dependent part of the cavity. This should emerge upon the loin. If the combination of transverse and vertical midline incision recommended by Cabot has been employed, great

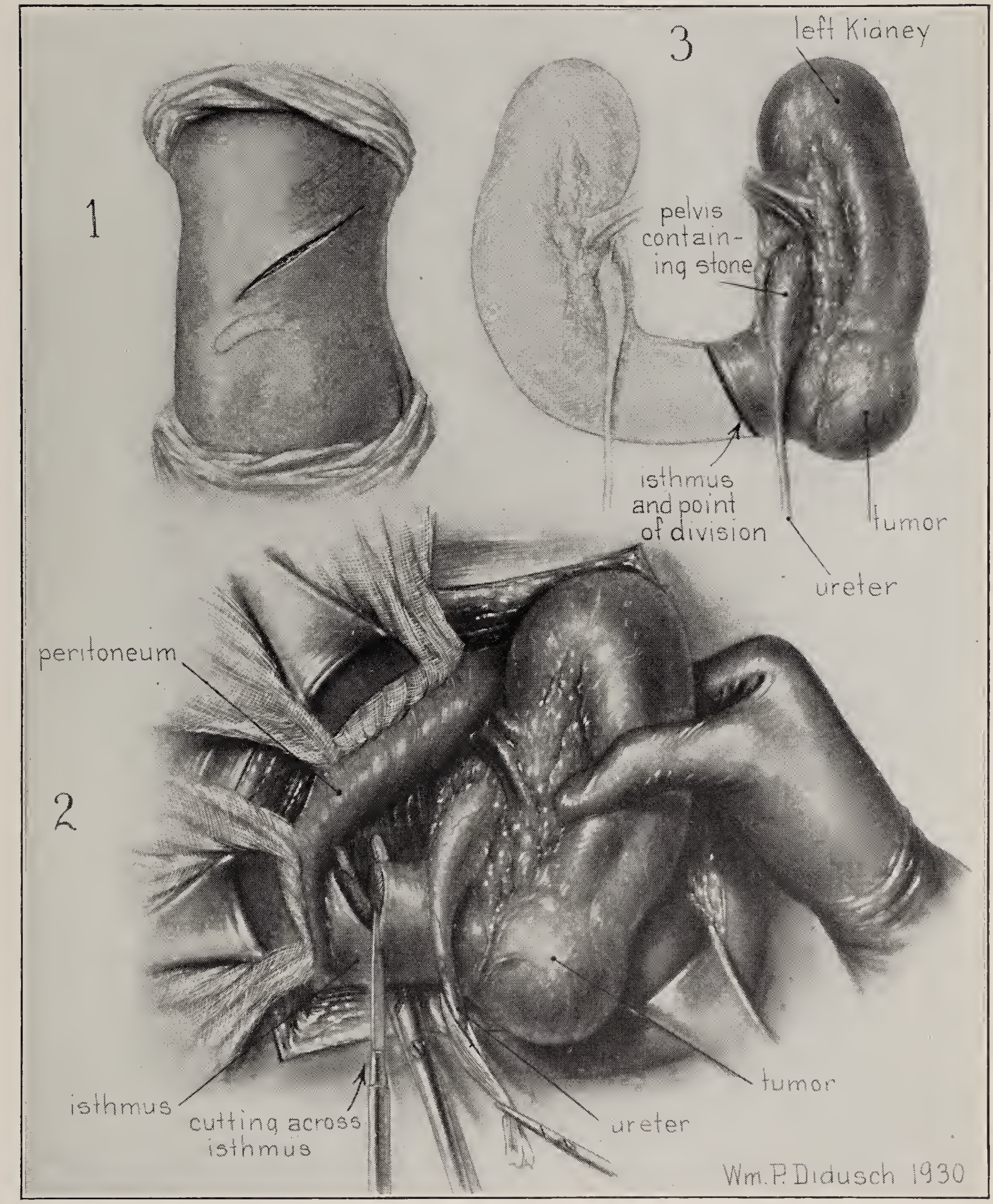


FIG. XXXIV. Surgery of horseshoe kidney. Bisection of isthmus in heminephrectomy for renal tumor. (1) Incision. (2) Division of isthmus. (3) Heminephrectomy for calculus and tumor.

care will be necessary in the repair of the abdominal wall. Extra heavy sutures must be placed at the angles. Though it is usually necessary to cut out a considerable area of peritoneum, this tissue is likely to have been so stretched by the growth of the tumor as to permit the remaining edges to be drawn together without undue traction. They should be sutured by a continuous stitch, catgut being the preferred material for this purpose. Certain operators place a few deep supporting stitches of silver wire as a reinforcement some little distance from the edge of the closed wound, drawing the skin together with metal clips in addition to the regular suture.

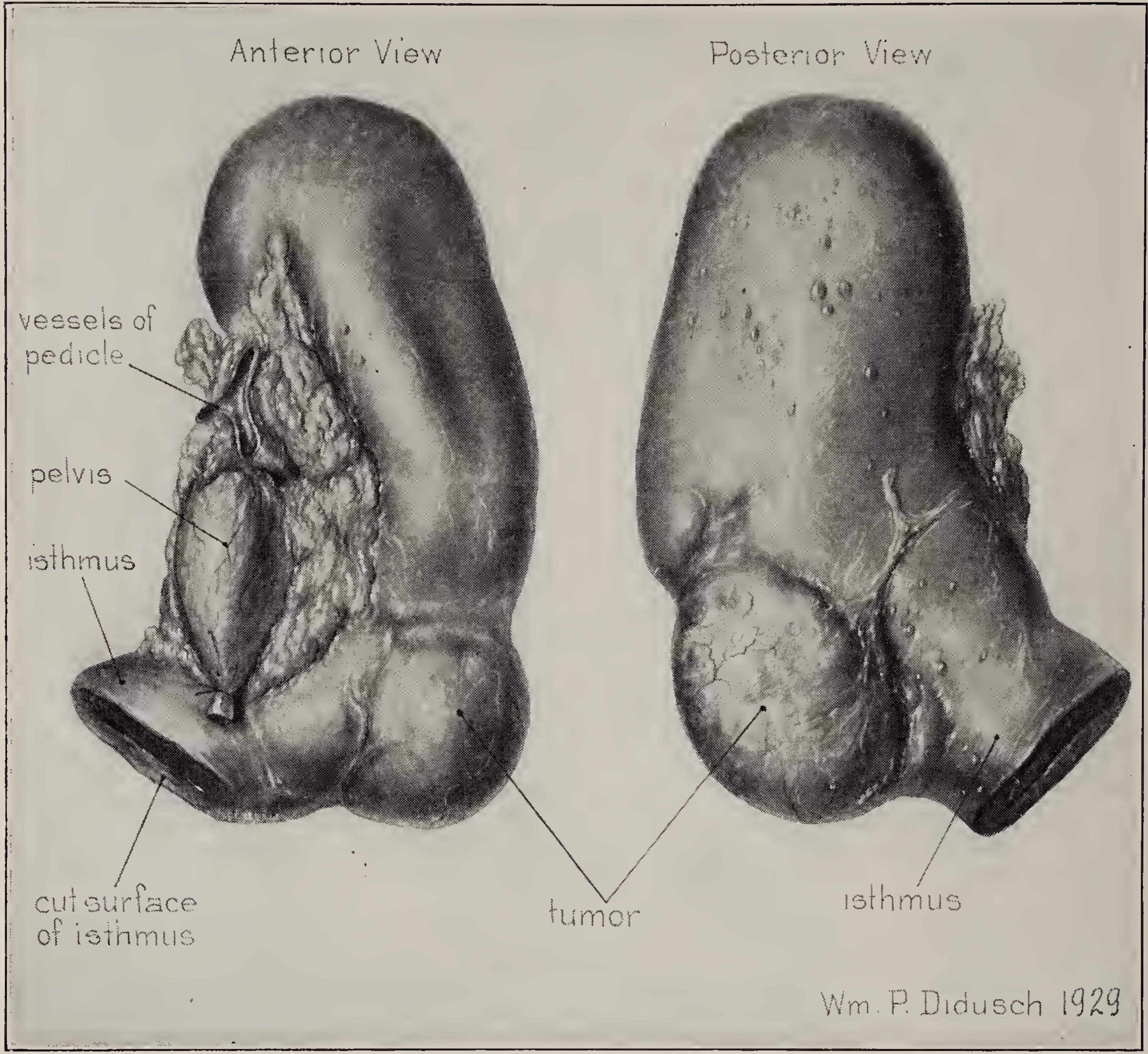


Fig. XXXV. Three views of excised half of horseshoe kidney. (*a*) Anterior view; (*b*) Posterior view; (*c*) Section. (See page 1093.)

Surgery of anomalous kidneys. Anomalous kidneys are more prone to disease than are those not differing from the standard pattern.

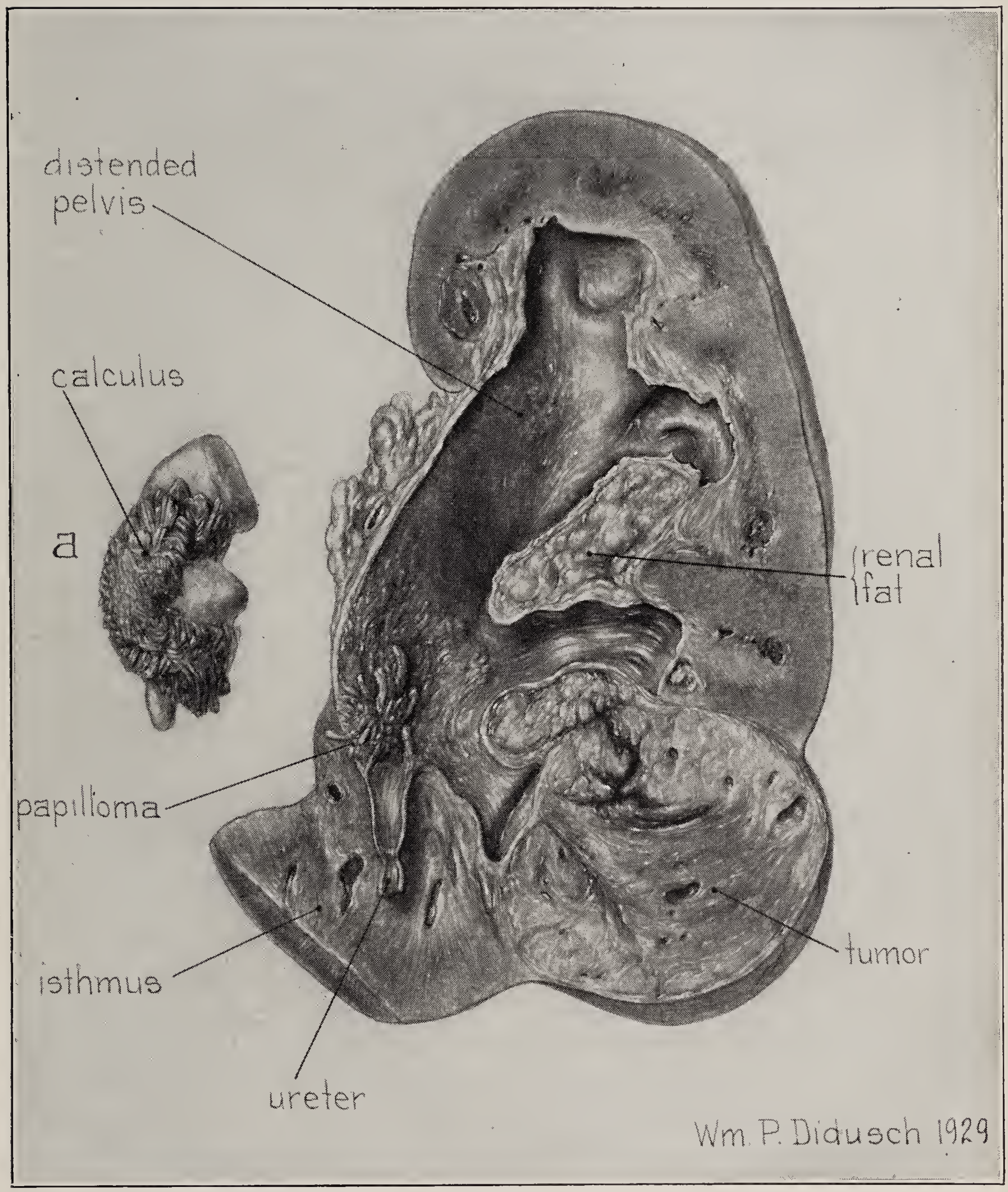


FIG. XXXV. (*c*) Section. (See page 1092.)

When this occurs the surgeon will often find considerable difficulty in carrying out an intervention which would cause no trouble if dealing with a normal organ. Our present diagnostic measures have afforded him much help and when a careful examination of the urinary tract has been made beforehand, he can usually make his preparations in accordance with these findings.

As a rule surgery directed toward the correction of anomalies is of little avail. Ectopic kidneys are sometimes placed in their normal position by nephropexy methods, but the wisdom of such procedures is questionable. Rovsing conceived a method for the separation of fused kidneys when functioning renal tissue cannot be demonstrated in the isthmus. This consisted in crushing the isthmus with a powerful clamp and permitting the two organs to shrink back into their normal beds. He claimed considerable success with this procedure, but the reports in literature are so uniformly unfavorable in the few instances where it has been tried by others, that I should myself never undertake it. Resection of a portion of a fused kidney has met with better success. The incidence of failure is about the same as that for kidney resections in general.

Accidents and emergencies. The great advances in renal diagnosis have done much to limit the accidents and emergencies which may arise in the course of operation upon the kidney. The surgeon who has trained himself to interpret his roentgenograms so that he is not dependent upon the opinions of someone else (who may be an excellent roentgenographer but not a practical renal surgeon) can proceed with a confidence no secondhand information will ever engender. Yet no single diagnostic measure can be relied on, and when all the evidence which the laboratory, the X-ray and the history sheet can offer has been weighed and measured, there remains the surgeon's own clinical findings and the results of his personal examination of the patient, which no competent renal surgeon will ever delegate to another.

Hemorrhage both during and after kidney operations is perhaps the most common emergency to be met. In nephrectomy it is most likely to take place after the clamp upon the pedicle is released following removal of the kidney. If vein and artery have been secured with three clamps, or at least two, before the ligatures were placed, such an accident is practically impossible. When but one clamp is employed the operator may fail to include all the vessels in the ligature, or a second ligature may have been placed over the first in such a way that the original one has ceased to be effective, and the second ligature severed when the kidney is removed. Digital pressure upon the pedicle may then be the only resort.

The bleeding after nephrotomy is often more difficult to control than when the kidney is removed entirely. The cautions regarding anomalous blood vessels should never be forgotten, no matter what the character of the intervention contemplated. The poles should be exposed slowly and carefully, a constant watch being kept for anomalous vessels, and in pyelotomy, no incision should be made until one is certain he will not run the chance of broaching an adventitious vein or artery. When bleeding takes place from sources other than anomalous vessels the pedicle may be temporarily compressed, the field cleared with hot sponges, and a search instituted for the source of hemorrhage. Often it can be located and the severed vessel ligated. If a small strip of fat be included in closing the nephrotomy wound the danger will be largely obviated, as approximation of the cut surfaces of the parenchyma with this section of tissue usually effects hemostasis.

No surgeon should undertake intervention upon the kidney without a thorough preliminary preparation in general surgery, and a very special training in the anatomy, physiology and pathology of the renal area. Not only must his manual skill be very great but his surgical judgment must likewise be of the highest order. Despite all the ways we now have of finding out the existing conditions before we expose the kidney, so many unforeseen complications may come to light at this time that previous preparation, no matter how complete, often fails to arm us fully against them. Though already frequently mentioned, let me emphasize once more the imperative necessity of making a full survey of the entire urinary tract, especially the condition of the opposite kidney. If what was expected to be a relatively simple pyelotomy should prove an extensive resection, or a complete extirpation of the kidney, exact knowledge of the condition of the unoperated organ may be of incalculable value. Many instances proving this might easily be cited.

If it becomes necessary to mobilize the twelfth rib — as not infrequently happens after incision has been made — great care must be exercised to avoid injury to the pleura, as this is likely to induce pneumothorax. A similar warning should be given against injury to the twelfth dorsal nerve which controls the lower segment of the rectus abdominis muscle. If this be damaged, paralysis of the muscle will ensue. Such an accident is most likely to occur when wide exposure for the removal of tumor has been necessary. The alert surgeon who knows his anatomy thoroughly should always be able to avoid it.

A final word should be said of the co-operation desirable — one is justified in saying *essential* — to success in this branch of surgery, perhaps more than in any other. The man who specializes in urologic operations is in great measure dependent upon the general practitioner for histories and clinical observations, and upon his laboratory and roentgenographic workers for much of his diagnostic data. The most complete frankness and sympathy should exist between all these collaborators, for it is only when their complete dependence one upon another is realized, that we can hope for the attainment of the greatest good to patient and physician alike.

POST-OPERATIVE CARE

The surgeon should never feel relieved of his responsibility when his patient is wheeled out of the operating-room in satisfactory condition. It is continually being realized that post-operative care in any intervention upon the urinary system is only slightly less important than the operation itself. Every efficient surgeon should actively concern himself in regard to this, seeing that the special needs of individual patients are supplied. He should not rely upon the regular hospital routine which may not be suited to the particular case in question, even though perfectly applicable to the "general run."

Vomiting. If the stomach has been lavaged after inhalation anesthesia, nausea and vomiting will be minimized. Patients who take regional anesthesia will not be troubled in this way. Fluids by mouth are likely to induce vomiting in etherized patients, so for the first twelve hours thirst can be assuaged and water depletion made up by making use of the Murphy drip, 10 per cent. glucose and 2 per cent. sodium bicarbonate being added to the water in most cases. Glucose 10 per cent. in intravenous injections of 30 cc. at a time, will usually stop vomiting, especially if it be due to acidosis. If vomiting persists after the first few hours, its cause is other than the direct influence of the anesthetic. It may be a paralytic ileus caused by trauma or an unduly prolonged operation. Occurring later, it is likely to indicate the beginning of peritonitis. Obstinate vomiting immediately after anesthesia may sometimes have to be relieved by further lavage of the stomach, but it has been my personal experience that this is seldom necessary. Vomiting is perhaps more in evidence after fixation of the kidney than following some other procedures. But any intervention which subjects the kidney to considerable manipulation tends to increase the tendency toward it. It was suggested not long ago by Lahey of Boston that all patients with late or persistent post-operative vomiting, or any obstructive symptoms, should have their wounds examined immediately for the possibility of post-operative wound separation. It is quite possible for the skin to heal and present an unbroken surface while all the structures beneath it may be wide open. Such an accident would be likely to happen only when the kidney had been reached by the abdominal route.

Hiccough. The subjects of renal operations are frequently troubled by post-operative hiccough. This is commonly attributed to a reflex stimulation of the phrenic nerves operating through the vagus nerves of the stomach. In renal operations it may well be due to deficient elimination by the operated organs. Selinger in a recent article, tabulates 23 suggestions for the control of hiccough, remarking that this is ample evidence that we do not know what causes it. Treatment is, therefore, purely empirical. In 1923, B. C. Sword of New Haven, Conn., tried the inhalation of carbon dioxide, using the Henderson-Coburn apparatus. He was moved to employ carbon dioxide because Henderson had shown in another connection that this gas stimulates peristalsis. It has been contended that diminished peristalsis is one of the causes of phrenic nerve irritation. At a recent meeting of the American Medical Association, R. F. Sheldon of Boston reported a series of cases where the method had proved useful in stopping hiccough. Before a different section at the same meeting Lahey likewise described his successful use of this plan. He found that no special apparatus need be employed. A small funnel is attached to an ordinary carbon dioxide tank. The patient inhales from the funnel until a mild hyperpnea results. Eight or ten breaths will usually abolish the hiccough. If the paroxysms recur, the inhalations may be repeated.

Stomach lavage, repeated as often as necessary, will frequently serve to allay hiccough, using a quart of warm water containing 2 drams of sodium bicarbonate. One of the remedies suggested by Selinger is a drop of tincture of iodine in a teaspoonful of water, repeated every fifteen minutes for six doses. Some operators use drugs such as chloral hydrate, epinephrin or the bromides. Others use morphine or cocaine subcutaneously, and in certain cases complete anesthesia has been employed; all with varying success. Most of these remedies have proved satisfactory to me at different times, but not long ago I had a patient whose hiccough persisted obstinately despite every known measure. In the absence of any known specific each practitioner must exercise his individual judgment.

Post-operative hemorrhage. Hemorrhage is perhaps the most dreaded post-operative complication in renal surgery, as in work upon other parts of the body. The control of hemorrhage during operation has already been discussed (page 1081). If proper precautions are observed at this time, post-operative bleeding should not take place. But if it does, in spite of all efforts to forestall it, the treatment should follow the general rules for the control of hemorrhage in any post-operative case.

In patients who have undergone nephrotomy, especially for calculus, or resection of the kidney for abscess, hemorrhage may start a considerable time after the wound has been closed. In most of these cases nephrectomy will be the best procedure. This can, of course, be done only when it is established beyond all question that the other kidney has sufficient functional ability to sustain life after its fellow is extirpated.

Diet. As soon as a patient can retain water taken by mouth the Murphy drip should be discontinued. Small quantities of water may then be permitted at relatively frequent intervals. When nephrectomy has been done, the work placed on the remaining kidney should be as light as possible until compensatory activity has time to become established. In patients who have lost much blood and are dehydrated, transfusion may be a wise measure, preferable to forcing fluids. The function of the remaining kidney should be constantly watched, the amount of urine excreted accurately measured and the administration of morphine or other drugs tending to inhibit excretion, kept at the irreducible minimum. If renal function remains good, even under the handicap placed upon it by the surgeon, the intake of fluids and soft diet may be increased with considerable rapidity. In general, proteins should be avoided and dependence placed largely upon carbohydrates, which supply much needed nourishment without undue strain on the renal apparatus which the extensive use of protein entails.

NON-OPERATIVE TREATMENT OF KIDNEY PATHOLOGY

Although in speaking of the treatment of various kidney conditions, a number of measures other than surgical have been discussed in the preceding pages, it seems wise to devote a separate section to special consideration of non-operative measures.

Establishment of drainage. It is often essential that a collection of fluid or pus in the kidney be evacuated when the patient's condition is such that surgical intervention is out of the question. Frequently, preliminary emptying of a hydronephrosis may make possible a satisfactory operation later on when the patient has had time to recuperate from the effects of the interference with urinary function previously suffered. Hydronephrosis as noted elsewhere (page 1019) is almost always dependent upon some type of ureteral obstruction — a kink, impacted stone, or stricture. If the condition be properly diagnosed before extensive renal damage has had time to take place, the removal of the obstruction is often all that is necessary to set matters right once more. Thus exploratory catheterization is often all that is required to open up the ureter.

Sometimes all symptoms will disappear following such a procedure, no other measures, either surgical or medical, having been brought into service.

Relief of hydronephrosis. Hydronephrosis is said to occur more frequently in women than in men. This is possibly because so-called "movable kidney" afflicts the female sex more often than the male, and hydronephrosis — dependent upon a ureter kinked by the abnormal position of its kidney — is that much more likely to be found in conjunction with it. If a ureter kinked in this way be splinted by the insertion of a catheter which then passes freely to the renal pelvis, there will immediately be a gush of urine, with rapid reduction in the size of the distended kidney. Occasionally a ureter so straightened will not again become occluded, but more often on withdrawal of the instrument the kink will return and the hydronephrotic sac quickly refill. A slightly mobile kidney is often retained in place by a proper belt and attention to the patient's general hygiene may correct the trouble without resort to surgery. If such a hydronephrosis depends on compression of the ureter by an aberrant blood-vessel, replacing of the kidney and straightening of the ureter is less likely to be effective. It may be that such a vessel will cause no trouble when conditions are otherwise normal. As removal of an artery may cause grave damage to the renal blood supply of the side affected, non-operative measures should first be put in practice, if there seems to be the least chance of their being effective.

Use of the indwelling catheter. An indwelling catheter left in place for some time often relieves an apparently desperate situation, making operative measures comparatively safe later on. If we are dealing with an infected hydronephrosis or a frank pyonephrosis, it should have the aid of suction. Such a case has been described by O'Conor. So large was the sac that 100 cc. of sodium iodide solution could be injected into it. The resulting pyelogram showed an opaque area filling the entire right abdomen from the costal margin to below the iliac crest. Previous to the injection, 1100 cc. of purulent fluid had been withdrawn by a syringe. At the same time 20 cc. of clear urine passed from the opposite normal kidney. The catheter was left in place for three days and suction frequently applied. The patient made a striking mental and physical improvement, so that the shell of kidney which remained was removed without danger, a procedure which would have been utterly out of the question at the time drainage was first instituted.

In many cases of acute pyelonephritis with high temperature and indications of severe systemic intoxication, immediate marked improvement follows the insertion of the indwelling catheter. In the pyelitis of pregnancy, the necessity for inducing abortion may sometimes be overcome by its employment. We must nevertheless beware of using it indiscriminately. Recently Shaw performed some animal experiments to discover how long an indwelling catheter could be well tolerated in the ureter. He came to the conclusion that the presence of the catheter if so large as to keep the ureter in a continual state of tension, could easily become a menace to the urinary tract's integrity, even if the ureter were perfectly healthy at the outset. In an acutely inflamed ureter the dangers would be infinitely greater. In his opinion, catheters larger than 6-French should rarely be employed in acute pyelonephritis, and these should not be permitted to remain in place continuously for more than twenty-four hours. If the conditions are such that any catheter smaller than No. 8-French will become occluded, the larger size should not be permitted to stay undisturbed in the ureter for more than twelve hours. The author's clinical experience bears out these observations, although he has found that catheters no larger than 6–French may sometimes be retained for longer periods without injury.

Irrigation of the kidney. In addition to the establishment of free drainage, every effort should be made to irrigate the affected kidney. To this end the patient should be encouraged to take as much water as possible, fluids of every kind also being forced. The blood urea should be frequently tested, together with the regulation procedures for determination of renal function. The heart should always be carefully watched, for if myocardial insufficiency exists or valvular disease is present, the forcing of fluids may be disastrous. Barring these cardiac complications there is practically no limit to the amount of water which a patient may take. The kidney is actually able to excrete more urinary constituents in a diluted urine than when the urine is highly concentrated.

Lavage of the kidney with the passing of the catheter to the renal pelvis frequently brings about complete amelioration of an inflammatory condition because it opens up an occluded ureter. This is why a single lavage so often appears to clear up a severe case of renal infection. Accordingly, credit will be given to whatever antiseptic agent the operator chanced to employ. Actually any one of a half dozen will be effective used in this way. It is not the fluid injected, so much as the instrument which conveys it, that promotes the return to normal conditions.

Pelvic lavage. For lavage of the renal pelvis the antiseptics most commonly employed are argyrol solution, 5 to 25 per cent.; mercurochrome, 1 to 500; or acriflavine, 1 to 4000. When a silver solution is used in the renal pelvis, it is well to limit the strength to 10 per cent. — or 20 per cent. at a maximum — although it is very generally employed in greater strength. The addition of normal saline solution and continued washing out of the pelvis after the silver nitrate has been injected, will at once relieve the pain. It should be remarked that silver nitrate is not at present used routinely in any of the large urological clinics.

The establishment of free drainage may be possible even in a kidney secreting a good deal of pus. This may be so abundant as to stop up the lumen of the catheter, so that a number of irrigations will be necessary to clear it away. The nature of the condition being treated must be carefully considered. It is unwise to use lavage when the inflammation is tubercular in origin, and it should also be avoided in calculus pyelitis, unless it be employed with the idea of sterilizing the field previous to operation for removal of the stones.

Disinfectants. It is possible to control pyuria to a certain extent by the administration of urinary antiseptics by mouth, but this therapy has very well defined limitations and on the whole, has never proved very efficient. Young advocates mercurochrome intravenously in the treatment of urinary tract diseases, and Leonard has called attention to hexylresorcinal as a valuable urinary antiseptic. In my personal experience, the last named drug has proved useful in handling *Staphylococcus aureus* infections, for which I find it much better adapted than is urotropine, which has found such wide employment for this purpose during the past few years.

Of urotropine or hexamethylenamine, it may be said that despite the popularity this drug has of late enjoyed, its use is decidedly limited. It is of no service unless the urine is acid, although the administration of acid sodium phosphate in conjunction with it brings about conditions under which it is efficient. In acid or acidified urine urotropine undergoes transformation into formaldehyde. In those infections which induce decomposition of the urea, the alkalinity present cannot often be changed by the ingestion of acid-producing drugs. The necessity for concentration and the time required for the accumulation of sufficient formaldehyde to be effectively antiseptic, make urotropine of little use in the majority of kidney infections. It may be of service in some cases of hydronephrosis, but in general, is more useful in the bladder than in connection with infections seated primarily in the kidney.

Still another urinary disinfectant which should be mentioned is pyridium. This is rapidly eliminated without change and has a high antiseptic value which makes it very useful under certain conditions. It seems especially adapted for action against infections of the coccus type. In colon bacillus infections it is not, in my experience, of much use. In general, it may be said that we are still waiting for the appearance of the perfect urinary antiseptic. Nothing at present available will be useful in all cases, and the idiosyncrasy of the patient, or the personal bias of the medical attendant will continue to bulk large in influencing the choice of the disinfectant most useful in urologic practice.

Tuberculin in renal tuberculosis. As a diagnostic agent tuberculin has proved very useful in renal tuberculosis. Often it has enabled the true nature of the affection to be established in time to apply curative measures while there was still good hope of success. As a curative agent its value is questionable, although in bilateral renal tuberculosis, where operative intervention is out of the question, the life of the patient may be considerably prolonged by a judicious use of this agent. Tuberculin, in itself, is not curative. Its function is rather to build up the patient's powers of resistance. Therefore, it should be employed in conjunction with other, well-recognized agents — outdoor life, forced feeding and so on — and never depended upon to sustain the struggle unaided.

Non-operative treatment of renal tuberculosis. Aside from the use of tuberculin a patient suffering from bilateral renal tuberculosis or otherwise unsuited to operative treatment, may be much benefited by the judicious employment of physiotherapeutic methods and proper attention to diet and general hygiene. Hematuria, if at all severe, causes a marked lowering of hemoglobin, necessitating a diet which contains a large proportion of iron. The well known calcium deficiency of the tuberculous patient demands food which will abundantly supply this element. It is generally conceded that a high protein diet puts added strain upon the renal apparatus, so it is logical to relieve a tuberculous kidney as much as possible by the elimination of proteins to a considerable extent. Green vegetables, especially spinach; cheese, milk, eggs, cereal and nuts, supply protein in more desirable form than does meat. Iron may be added if desired. The normal processes of digestion and elimination may be aided by the ingestion of bran and a variety of fruits.

Diathermy and hydrotherapy. Much relief is often afforded to those afflicted with renal tuberculosis by the use of diathermy which acts to increase the specific gravity of the urine, thus lessening the frequency and pain of urination, so distressing in most of these cases. Using a 6-inch electrode applied just behind the kidney, and an 8-inch one in front, a 500 milliampere current may be employed at the outset, gradually increasing to double that amount. The applications should at first be limited to ten minutes, lengthened by degrees to a full half hour. Heat applied in this way is a most effective bactericide, and by reducing the infectious agencies, strengthens the patient's resisting powers, aiding the kidney to fight against the disease.

Hot moist applications and hot sitz baths are highly recommended by certain therapists who give special attention to the treatment of this form of tuberculosis. Certainly, the general tonic effect of hydrotherapy serves to help the patient whose disease is seated in the kidney quite as much as it does he who suffers from some other form of tuberculosis. All subjects of renal tuberculosis should be hospitalized if possible. It is even more necessary than for phthisis patients, though this fact is very seldom recognized. Under regular sanatoriom care the diet can be regulated and such physiotherapeutic measures applied as may seem necessary. These conditions are impossible of attainment in the average private family.

Heliotherapy. In the immediate post-operative care in the Brady Urological Clinic of the New York Hospital heliotherapy has proved most beneficial in managing renal tuberculosis. Its value has been attested in hundreds of inoperable cases. While natural sunlight is probably better — if attainable in unlimited amount at the exact time required — man's agelong disadvantage when it comes to controlling the weather makes sunlight treatment out of the reach of most of us. The mercury vapor quartz lamp or Alpine light, as it is more generally called, has, in my experience proved a most efficient substitute for real sunlight, even advanced cases of bilateral renal tuberculosis deriving much benefit from its use. We have found it almost a specific for post-operative tuberculous sinuses of the genito-urinary tract. Sufferers from bilateral renal tuberculosis who cannot be operated upon are given lamp treatments over the kidney region. So far the results have not been particularly brilliant, but many of the patients have expressed themselves as feeling benefited by the therapy. We have also found heliotherapy and the lamps useful in those cases where one kidney has been removed and tuberculosis has later manifested itself in the remaining kidney. Old tuberculin is usually given hypodermically in serial dilutions, in addition to the physiotherapeutic procedures. Some patients who were wholly unfit to stand the strain of operation when first seen, have been so benefited by this therapy as to later undergo nephrectomy with fair hope of relief.

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I

TRAUMATIC INJURY TO THE KIDNEY

In general, the kidney is seldom subjected to traumatic injury, probably because of its well-protected position beneath the ribs. In extensive trauma to the abdomen and pelvis — crushing accidents, gunshot wounds and the like — the laceration of the surrounding structures will usually be so extensive that the damage to the kidney will by comparison, be of small account. Indirect trauma is a cause of many renal injuries — violent jolting, falls from considerable height alighting upon the feet, and similar indirect forces being the usual causes. Muscular action — dodging, leaping or heavy lifting — has been known to produce kidney rupture, and when the injury to the kidney has been brought about in this way it is very often unrecognized until the condition of the injured organ has become very serious. Severe injury may result from very slight trauma — sometimes so trivial that the patient pays little or no heed to it at the time it occurs. The symptoms are often so slow in manifesting themselves that before hematuria or other signs appear he will have completely forgotten how or when he was injured. The damage done to the kidney by trauma may vary all the way from trivial tears of the fatty capsule, localized subcapsular hemorrhage, slight contusion or laceration of the parenchyma, to rupture of the renal pelvis, extensive injury to the blood vessels, complete tearing apart of the organ, or its reduction to a pulp. These injuries may or may not be complicated by additional trauma to the peritoneum, or other neighboring tissues.

Symptoms of renal involvement. When the kidney has been injured, if the peritoneum has also suffered trauma — as is likely to be the case — the boardlike rigidity or "abdominal defence" commonly encountered in abdominal lesions will be manifested. Nausea and vomiting are also prone to occur. If the kidney alone has suffered injury these abdominal symptoms are not so likely to be in evidence, but if there chances to have been extensive loss of blood, the taking of the leukocyte count will reveal its rise to twenty or thirty thousand. If enough time has elapsed for infection to take place, there may be elevation of temperature, even as high as 105° F. Shock will, of course, be in evidence in cases of extensive injury of surrounding structures, and also when the kidney is the only organ affected. The greatest danger is from hemorrhage, and in immediately fatal cases death is practically always attributable to this cause. Infection is almost as grave a danger, but if the wound comes promptly to the surgeon's attention, so that early exploration may be undertaken, even some badly damaged kidneys may be saved and restored to usefulness. As the infection is likely to take the form of a diffuse cellulitis, it is very difficult to control when once established, but if seen soon enough to be sutured and properly drained, the chances of a favorable outcome are considerably enhanced.

Trauma to diseased kidneys. In industrial accidents the question as to whether a kidney was healthy previous to the accident may have an important bearing on the matter of compensation, as it is well established that trauma where a pathologic condition already exists, is likely to do far more injury than to a kidney previously sound. A careful history, whenever it is possible to obtain it, may be of value in elucidating this point, as well as in influencing the prognosis which the surgeon is able to offer. Very careful examination may be necessary in order to establish the preëxistence of some disease or lesion of which the patient may very likely have been ignorant. For what is occasionally termed " the silent kidney " can harbor tuberculous infection, stones or even tumors without offering a single sign arresting enough to direct attention to the renal region. In any kind of industrial or insurance work the clearing up of such points may be of great importance.

Gunshot wounds. Direct trauma may result in contusion or rupture of a kidney, but gunshot wounds, which are a fairly frequent form of traumatic renal injury, are in nearly all cases perforations, usually associated with similar injury to the surrounding organs, notably the intestines and stomach. Every traumatized kidney should be explored to determine the nature and extent of the injury, if there is any reason to believe that it is extensive. When doubt exists, and roentgenographic examination does not supply sufficient information, a surgical investigation is really the more conservative course. When the wound has been made by a bullet and other organs are involved there may be some question as to the best method of reaching the site of injury, that is, whether it will be wiser to first open the abdomen, or to commence by a lumbar incision for exposure of the kidney. If hemorrhage is severe, and known to have its origin in the kidney, the wiser plan will be to commence with the lumbar incision. In this way infection of the retroperitoneal space by contamination from a punctured intestine will be avoided. For the same reason the lumbar, rather than the transperitoneal incision should be employed. This holds good whether the kidney is merely examined and left untouched, or when it becomes necessary to remove it altogether.

In general, it may be stated that a badly ruptured or perforated kidney cannot be saved. If the main arteries or veins have been damaged beyond functional repair, nephrectomy is the only course. Partial excision has worked well in certain cases, as the ability of the kidney to repair extensive damage probably exceeds that of any organ in the body. The condition of the blood-vessels is perhaps the most important consideration, but when hemorrhage is very free, it is sometimes difficult to find out just how much injury these have sustained. It goes without saying that whenever possible the functional ability of the uninjured kidney should be determined. In desperate cases, this is very seldom practicable, and where death is practically certain if the traumatized renal organ is permitted to remain, the chance of the surviving organ's being able to carry on renal function for both sides, will have to be taken.

Spontaneous rupture. Though spontaneous rupture cannot properly be classed as a kidney trauma, and is moreover, a very rare occurrence, it has happened often enough to deserve mention as a possible

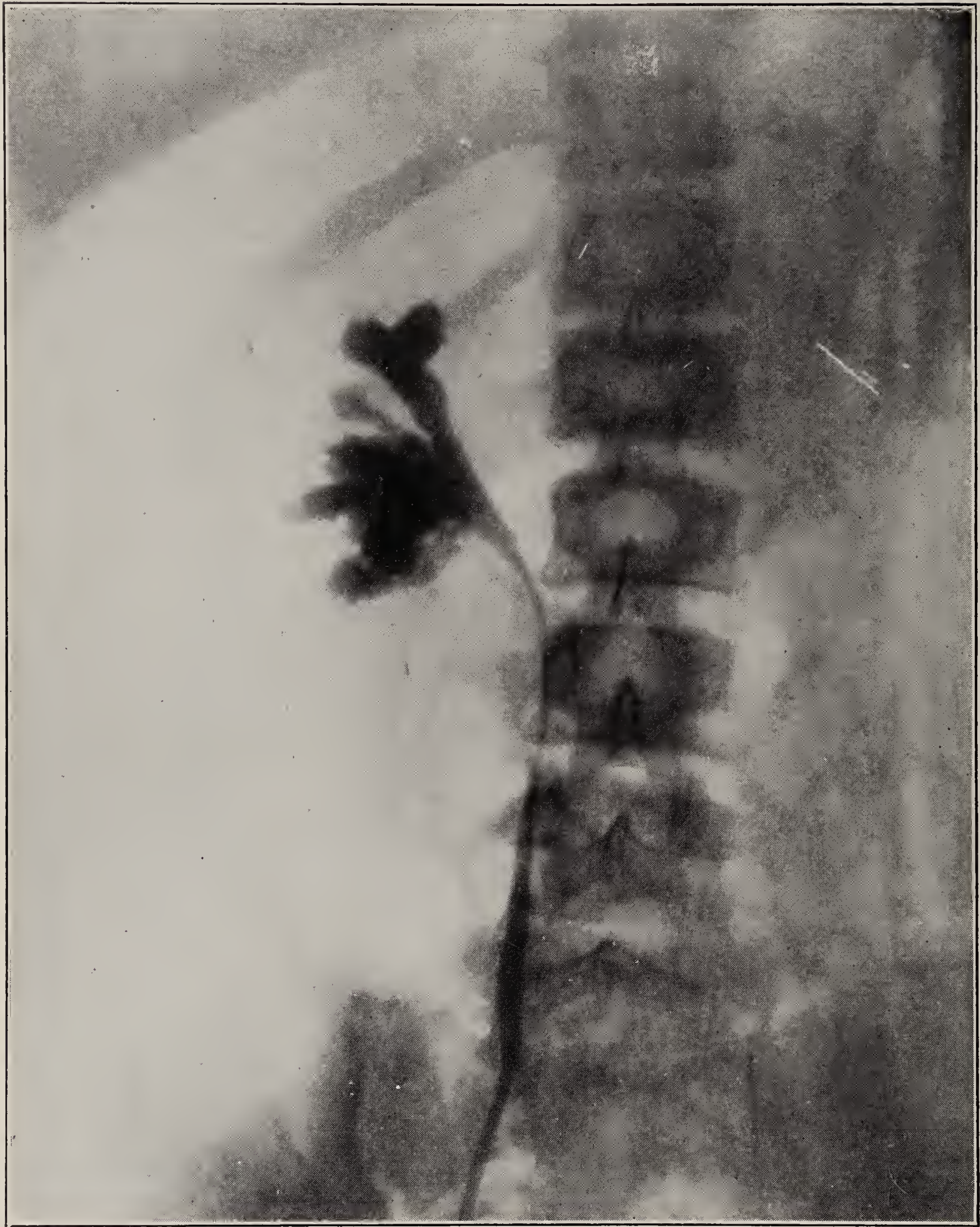

FIG. XXXVI. Pyolegram showing extravasation of medium (sodium iodide) in case of ruptured kidney. (Courtesy of James Buchanan Brady Foundation for Urology of the New York Hospital.)

emergency which the renal surgeon may be called upon to meet. The rarity of spontaneous kidney rupture was demonstrated by my colleague, Henline, who was able to find but twenty-four reported cases in addition to one occurring in his own practice. The causes were variously stated as tuberculosis, tumor, abscess, necrosis of the suprarenal, traumatism and hemophilia, and all authors agreed that chronic nephritis was present in every case. Henline added hydronephrosis and pyelonephrosis secondary to ureteral obstruction as capable of inducing spontaneous rupture.

In a kidney previously diseased, very slight indirect trauma is doubtless capable of causing rupture. The immediate symptoms are similar to those of ruptured spleen — acute pain usually, but not always referred to the lumbar region, the characteristic signs of internal hemorrhage and shock, and after a short interval, the development of tumor which may at times be recognized as retroperitoneal. The involved kidney will be tender on palpation if the patient's condition is such as to permit such examination, and rigid muscular defense will be in evidence. In four of the collected cases the urine was normal on examination; in nine hematuria was present; the remaining eleven showed some form of chronic nephritis. In Henline's case there was no sudden onset, but rupture permitted the formation of a perinephritic abscess which burrowed its way entirely through to the suprapubic region, without any definite manifestations relating the symptoms thus produced to the kidney. The impacted ureteral calculus, which caused the hydronephrosis and thus indirectly, rupture, had never given the patient any inconvenience sufficient to cause him to seek medical advice, although he had on two different occasions previously, passed a stone. Most of the cases are fatal. Early diagnosis, permitting the prompt removal of the damaged organ, or the establishment of efficient drainage, is the only hope.

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II

RENAL DISEASES

An enumeration of " renal diseases " might very properly include every type of kidney disturbance except those induced by trauma. Even these injuries would, in all probability, develop a secondary infection, making them eligible for inclusion in the " disease " classification. The generally accepted meaning of *kidney disease* appears to be rather those conditions to which medical treatment is applicable, and in the correction of which the surgeon is not invited to share. " Surgical diseases of the kidney " are regarded as outside the limits of " kidney diseases " in general. Modern methods of treatment have tended to break down these distinctions, and to blur the line of demarcation between *medical* and *surgical* forms of renal pathology. We now use surgery to cure many conditions which were formerly left to medical treatment, and on the other hand, symptoms which we once thought could be relieved only by nephrectomy, or some almost equally radical measure, now yield to the far less drastic therapeusis which recent experimentation and observation has placed at our disposal.

Inflammation of the kidney and its pelvis. Up to a very short time ago nearly every kidney disturbance was diagnosed as " nephritis " or " pyelitis." The discovery of Roentgen which first enabled us to detect urinary concretions, renal enlargements and displacements and similar gross abnormalities, was later made still more valuable to renal investigators by the introduction of opaque media which soon brought the art of pyelography up to a high standard, and showed in many cases that the supposed " inflammations " were due to congenital abnormalities, new growths or a multitude of other phenomena, of which the " inflammation " was only a secondary manifestation. Consequently the terms nephritis and pyelitics are no longer exact, and in the writings of different men, or in varying geographical localities, are used in distinctly unlike ways. Nephritis, indeed, has come to mean anything wrong with the kidney which cannot be definitely postulated as stone, tumor or something equally precise; pyelitis, on the contrary, has come to be limited in its application to the type of kidney infection so commonly seen in female children and the renal disturbances of pregnancy. This lack of standardization in nomenclature and definition of terms greatly enhances the difficulties of him who would furnish some understandable information regarding the commoner diseases of the kidney, and the immense amount of experimental and clinical work which has been carried out and reported in literature during the past decade has only served to make his task the harder. It will be my endeavor to limit the discussion which is to follow to those pathologic conditions of the kidney to which surgery is not usually applied, and to subdivide these conditions into groups, largely upon a basis of likeness in general symptomatology.

Two general types of nephritis. In a study recently published by three members of the staff of the Middlesex Hospital, London, an excellent division according to prevailing manifestations was made of kidney diseases in general. Type One is characterized by edema; while Type Two is associated with high blood pressure and other cardiovascular phenomena; nitrogen retention in the blood; and uremic symptoms. The distinction between the two types is thus tabulated:

Type I	*Type I*
Edema.	No edema except from cardiac failure.
Normal blood pressure.	Raised blood pressure.
No cardiac hypertrophy.	Cardiac hypertrophy.
Oliguria.	Polyuria or suppression of urine.
Marked albuminuria.	Slight albuminuria.
Normal excretion of urea.	Urea excreted in low concentration.
Urine of high specific gravity.	Urine of low specific gravity.
No nitrogen retention.	Nitrogen retention.
No signs or symptoms of uremia.	Uremia common.

Attention is called to the recent work of Munk, who believes that all renal disease with edema but without cardiac failure, should be designated as *nephrosis;* whereas true *nephritis* is characterized by hematuria, uremia and cardiovascular complications. The lesions of the nephrotic kidney are *degenerative*, rather than *inflammatory*.

A slightly differing classification is that advocated by Thomas Addis three years ago. He regarded all manifestations of " Bright's disease " as capable of being classed as (1) hemorrhagic; (2) degenerative, or (3) arteriosclerotic. The first is " the glomerular nephritis of the pathologists," characterized by the presence of blood casts and of an abnormal number of red blood cells in the urine. Of the second type are any pathologic renal conditions which may give rise to degenerative changes in the kidneys. Here are placed cases of unknown etiology, seldom seen until edema has developed, with marked lipemia in the active stages, which may pass through active and latent periods to complete recovery, or death because of uremia; cases of renal injury by mercury or other chemical poisons; the small class of patients who have suffered a permanent renal injury from the degenerative nephritis of pregnancy; the toxemias which may accompany any general infection; the cases of renal degeneration traceable to focal infection, usually staphylococcal; and finally the ‘ waxy kidney ’ found in infections of long standing such as osteomyelitis with sinus formation, which sometimes induces a slowly progressive renal degeneration leading to uremia. The third, arteriosclerotic type of nephritis is the most frequently seen, and therefore, the most important to the general practitioner. But regarded as a purely renal lesion clinically considered it is of little consequence, “ for when the diagnosis is made it is no longer necessary to consider it as a factor in the management of the patient.” There is actually little difference between the American and British classifications, as the arteriosclerotic type of Addis is included in the Type Two of the Middlesex Hospital men. Addis remarks that the degenerative form is not, like the hemorrhagic form, a unity, but only a convenient term under which to comprise all those pathologic conditions which may give rise to degenerative changes in the kidneys. But at best, exact classification is difficult, and many points in etiology and pathology—to say nothing of treatment — still remain to be cleared up.

Structure of the kidney in relation to disease. The peculiar mechanism of the kidney, and its physical equipment, have, of course, a very great influence upon the types of disease by which it is attacked. It must be thought of as composed of a great number of secreting units, each of these units consisting of a glomerulus and its tubule, with its accompanying tuft of blood-vessels, and the connective tissue which fills up the space intervening between each unit and those adjoining it. Separate members of this unified group may be, and often are, individually diseased, which makes for still greater confusion in postulating such disease or properly interpreting its clinical manifestations.

Moreover, we have recently come to realize that some portion of the kidney may sustain a very serious lesion without its producing any striking symptoms, and a long, slow process of healing eventually set in which is seldom or never recognized unless the subject comes at last to the autopsy table, having died usually of some unrelated condition, and the scars of this old process are detected upon examination of the kidney. Rathbun and Alter not long ago described what they termed a “ surgical nephritis,” reporting three cases in which nephrectomy was done, though, in their own words, "it was doubtful if nephrectomy was logical in any of them." The excised kidneys on section showed well-defined infarct-like areas. On the surface of the kidney these areas appear as slight elevations or depressions. There were scar-like areas which suggested the healed infarcts seen in endocarditis, or certain types of arteriosclerosis. Inflammatory changes were found in the walls of the arteries, the walls of the vessel becoming indistinct, the adventitia invaded by inflammatory infiltration of lymphocytes and polymorphonuclear leukocytes. A process of thrombo-andarteritis was observable in various stages according to the age of the infarction, which eventually heals leaving the scar. The clinical symptoms which led to the performance of nephrectomy were judged to have been induced by anatomic changes taking place in the renal parenchyma at a certain stage of this process, and were therefore quite unlike those which indicate the existence of an acute renal infection. The existence of this type of renal disease is so seldom recognized that it seems excessively rare. Whether this is actually the case only much further study and investigation will reveal.

Acute nephritis. Type One of the classification first mentioned finds its characteristic representative in the condition usually termed *acute nephritis*. It takes its place also in Addis's *hemorrhagic* classification.

Etiology. Some sort of infection is the usual cause of acute renal inflammation, that of scarlet fever being perhaps the one most frequently encountered. Many cases formerly regarded as of highly mysterious origin are now understood to be due to focal infection, the organisms having been carried to the kidney by the circulation. In acute pyelitis — that is, where the inflammation is confined to the renal pelvis and its parenchyma, the organisms may be carried in by injudicious use of the ureteral catheter. I have no time to enter my lance in the never-ending tournament over the relative probability of *ascending* or *descending infections*. I will merely state that my experience leads me to believe that both are possible, but that blood-borne infections of the renal organs seem to me to have probability on their side. The experiments of Bumpus and Meisser of the Mayo Clinic appear to have demonstrated beyond reasonable doubt that pyelonephritis arises because of the existence of foci of infection in parts of the body other than the kidneys — the teeth and tonsils most often — whence are distributed streptococci which have a selective affinity for the urinary tract. Acute kidney or renal pelvis inflammation may follow the ingestion of poisons such as bichloride of mercury.

We are as yet unaware of the exact mechanism by which inflammation arises, or why the kidney is frequently able to eliminate virulent bacteria which have gained entrance to other portions of the body without any injury to itself, but again, may be overcome by an infection even more severe than the primary one. As has been pointed out by Lee-Brown, the result is probably decided by the maintenance or disturbance of the balance between the virulence of the organisms and the immune reactions of the body both local and general.

Possibility of a bacterial toxic origin of acute nephritis. The bacterial toxic origin of most cases of acute nephritis was well discussed in an able paper published several years ago by John Gray of Aberdeen University. His experiments showed that nephritis produced by simple crystalloid chemical substances is always tubular, when small dosage is used, and he explains this distribution on the basis of the 'modern' theory of renal function. Therefore, the alleged 'glomerular' crystalloid poisons are really primarily tubular in incidence. As toxins are colloids they are not filtered through healthy glomerular tufts; so, when fluid is withdrawn in the filtrate such toxins are concentrated in the glomeruli. Nephritis, thus produced, will be essentially glomerular. In accordance with these views, Gray outlines the successive stages of an acute nephritis as follows:

A. *Ordinary type* (*bacterio-toxic*) Concentration of circulating exotoxin (often streptococcal) in the glomeruli. Simultaneously there may occur bacterial 'embolism' in the glomeruli, with lysis and local release of endotoxin.	*Endo-glomerular nephritis*
Continuation of above, but emboli factor and consequently endotox factor soon drops out.	*Epi–* and *Endo-glomerular nephritis*
Glomeruli become toxin- and albumin-permeable Commencing concentration of toxin in the tubules	*Glomerular-tubular nephritis*
Further increase of hyper-permeability of glomeruli; hence further increase in tubular concentration of toxin, and coincident decrease of special concentration of toxin in the glomeruli.	*Mainly tubular nephritis*
B. *Acute interstitial nephritis.* Nephritis with a more prominent bacterial factor than the above, and showing some multiplication of organisms within the kidneys.	
C. *Acute suppurative nephritis.*	

If this scheme is a correct conception, Gray feels that theoretical considerations would of themselves, place streptococci as amongst the organisms most likely to cause ordinary non-suppurative nephritis.

Clinical manifestations. Edema and hematuria are the outstanding features of acute nephritis. Headache, vomiting, dyspnea (which was especially marked in the type designated 'war nephritis'), pain in the lumbar region, and oliguria are usually, but not invariably, in evidence. Initial oliguria sometimes gives place to excessive secretion as soon as improvement sets in, but not infrequently there is complete suppression of urine at the onset of the attack. Albuminuria is always marked in the beginning, and may persist indefinitely, long after the patient is apparently in full health once more. Fever is often present, and in pyelitis especially, may be the most noticeable manifestation, but often again, the entire course of the disease will be afebrile, even while the urine is continuously loaded with pus and virulent organisms. Physical examination is, of course, very important, but the individual consideration of the urinary findings is even more so. Use of the cystoscope and intelligent employment of the renal function tests mentioned elsewhere (see page 1010) should serve to establish the diagnosis.

Too much reliance, however, should not be placed upon the functional tests. They are to be used rather as confirmatory evidence of the clinical findings. Their place in the diagnosis of nephritis has been very illuminatingly discussed by Wearn. He cites the observations of Richards on frogs as an aid in understanding the mechanism of these tests. This observer examined the glomerular circulation in the living frog's kidney, noted the intermittence of blood flow through them and how a single capillary loop opens into one glomerulus to permit a rapid flow of blood with the corpuscles in single file, while a nearby glomerulus opens all its loops widely to permit a lazy circulation with two corpuscles abreast. Only a few glomeruli are active at one time; a large reserve is always inactive. When the frog subject was plied with diuretics, urea, salt, glucose or water, many hitherto inactive glomeruli were stimulated to work, and those which were already active began to excrete urine so rapidly that the capsules of Bowman were distended and stood out "as tense little blisters on the surface of the frog's kidney." Disease may destroy the glomerular unit, or can alter it so that its efficiency is greatly decreased; or both conditions may arise at once. The tests are therefore of two kinds; they either measure the kidney's output during a given time, but impose no additional work upon the functioning organ; or they are designed to test the kidney's ability to respond to a sudden strain. Of the second group of tests but little use is made in what are termed "medical" conditions. Of the first the best known and most employed is the phenosulphonaphthalein test of Rowntree and Geraghty. This test does not furnish any idea of how great a reserve of units the examined kidney may still possess, so there will be no reduction in the dye output until these reserve units are either greatly damaged or wholly destroyed. Blood nitrogen increases only after the units have been so injured that they are no longer able to keep pace with the protein intake; this occurs only when the renal disease is well advanced, but the sign having been noted it is of value in pointing out the necessity of dietary regulation in regard to protein intake. The tests thus have many uses, and should never be omitted. Their proper evaluation and employment is none the less essential.

Treatment. As we have no direct access to the kidney for medical treatment, this inevitably resolves itself into putting the organ at rest in so far as is possible and so arranging conditions that the damaged renal tissue will have opportunity for regeneration. If there is retention of nitrogenous waste products in the blood, a low protein diet is absolutely essential, and in general, is required throughout the early stages. MacLean, whose word is authoritative, regards it as a mistake to limit the protein intake too severely for long periods, as is frequently the practice, especially when albuminuria is in evidence for a long time. In some of these cases where edema is persistent, the amount of protein actually passed in the urine may be so great as to constitute a serious loss, and in such cases he regards protein restriction as worse than useless. The behavior of the protein is probably dependent to some extent on the diuretic action of the urea formed as a result of increased protein metabolism. He prefers to give more, rather than less, protein in cases showing extensive albuminuria, and has not found that it appreciably raises the percentage of albumin in the urine. Milk, the old-fashioned ‘ stand-by ’ in kidney disease, he thinks should be used sparingly, or not at all. Glucose solution is useful in cases displaying much nausea and vomiting. In a 50 per cent. solution a good deal of nourishment is provided while the ingestion of water is kept down, thus lessening the strain on the diseased kidneys. Glucose requires no digestion to prepare it for absorption, and administered by the Murphy drip method, has proved useful in handling urologic cases of many kinds. Carbohydrates, such as are supplied by bread, cereals and a little later, rice and potato, should replace proteins largely or entirely until convalescence is well established. Fluid and salt intake must be generally restricted, so long as edema is in evidence. Diuretics, which were formerly much favored, have now fallen under the ban of many internists. Christian of Boston, for example, recently stated that he now omitted them altogether from his therapy of acute nephritis.

Treatment of pyelitis. In handling acute infective conditions confined to the pelvis and calyces, somewhat different local conditions must be met, and instead of limiting the fluid intake it is increased as much as possible. The pyelitis of pregnancy offers some special problems of its own. Pyuria is its most outstanding symptom and the usual indications of systemic infection are in evidence, though in mild cases there may be little or no rise of temperature. Abundance of pus in the urine is a good sign rather than the contrary, as it indicates that good drainage is being maintained. If there is inflammatory occlusion of the ureter, the urine may for a short period be absolutely negative. The organism most commonly detected is the colon bacillus, which is likewise most prevalent in the cases of pyelitis seen in little girls. In the chronic cases pelvic lavage is indicated and often proves of great value, due doubtless, quite as much to the opening up of drainage by the passage of the ureteral catheter, as to the healing effect of the drugs employed in the irrigating solution. Silver nitrate, 1 to 2 or 3 per cent., or mercurochrome in about the same dilution are those most commonly used. Mercurochrome has also been used intravenously — five milligrams of a one per cent. solution per kilogram of body weight being the customary dosage. As chronic pyelitis is apt to be dependent upon some primary focus in teeth, tonsils or elsewhere, it is an essential part of its therapy to get rid of all such foci.

Chronic renal inflammation. When the acute stage of a streptococcal or other infection of the kidney has subsided there is often a prolonged period of latency which is taken by both patient and physician to be complete restitution of renal competence. In many instances the infection is retained in the renal tissue, or if complete healing has taken place there, the original focus or foci of infection still remain, ready under suitable conditions to reinfect the peculiarly susceptible kidney. Addis states that he has had patients remain in this latent stage for as long as ten years, only continuous examination of the urine giving any indication of abnormality. And urinalysis often showed no more than an abnormally high number of red blood cells and a few blood casts. The slowly progressive glomerular destruction is met, he tells us, by a steady compensatory hypertrophy.

Chronic interstitial nephritis. Chronic nephritis usually, though by no means invariably, originates in an acute kidney inflammation which degenerates into a more or less chronic form. The type most often seen is what is known as ‘ chronic interstitial nephritis ’ to the English-speaking medical world, and called by the French the *type azotaemique.* Here we have failure of proper excretion of nitrogenous products by the kidneys, with their consequent retention in the blood. The manifestations conform to the Type II of the Middlesex Hospital men, in that nitrogen retention and a tendency toward uremia are marked features, and edema is wholly absent or noted only in association with cardiac failure.

Chronic parenchymatous nephritis. When the kidneys fail in their proper elimination of salt we are confronted with a condition generally termed *parenchymatous nephritis*, and called by MacLean the *hydremic type*. As is suggested by this title, the urine contains little or no sodium chloride, and edema is the most overwhelming symptom. The distinction between the two types of chronic nephritis cannot be made very clear-cut. Often the same individual will present irregularities of kidney function which place his case in both classifications, and in general, the tendency of hydremic nephritis is toward the conditions attending nitrogen retention which eventually terminate in uremia. It seems probable that the particular toxin giving rise to the purely degenerative lesions of the kidney may be something entirely different from the cause of degeneration as associated with inflammation, We have no precise method of distinguishing differences when the disease is still in its early stages. It is merely an assumption that in the kidneys of a subject of hydremic nephritis sufficient inflammation takes place to produce the chronic interstitial form which is usually the terminal stage of any chronic nephritic condition.

Lipoid nephrosis. Though what has already been said indicates that there can be no hard and fast distinction between inflammatory and degenerative diseases of the kidney, it would seem to clarify the situation somewhat to apply the designation *Nephrosis* to any condition in which inflammation does not seem to play a leading rôle, so far as can be determined by the tests now at our disposal. *Lipoid nephrosis* is described by Munk as an insiduous disease, seen almost entirely in young subjects, wherein the urine shows a tremendous amount of albumin but no blood, oliguria, normal excretion of nitrogen and normal blood pressure, but an excess of cholesterol in the blood. The most striking characteristic is edema, often intense, amounting to true anasarca, while an invariable urinary finding is doubly refractive lipoids. Bennett and his coworkers comment that apart from albuminuria, it is difficult to adduce any clinical evidence of renal disorder in the ‘ dropsical ’ type of nephritis. The ‘ myelin kidney ’ is probably the extreme development of the common anatomical change in this condition, which in milder cases exhibits itself merely as lipoid degeneration of the renal tubules. “ From the conception of ‘ nephrosis,’ a purely degenerative lesion, by Müller in 1905, the recognition of doubly refractive lipoids in the myelin kidney by Kaiserling and Orgler in 1902, and the discovery of hypercholesterolemia in renal edema with albuminuria by Chauffard and Widal in 1911, have arisen the modern views concerning the condition now commonly described as lipoid nephrosis.”

Clinical and histological features. The various clinical types which may be grouped under this heading were well illustrated in six cases reported by Dyke in 1924 under the title *Pathology of Nephritis Associated with Œdema.* The one feature all had in common was edema of an extreme degree, while histologically every one showed a very marked degeneration of the tubular epithelium, " accompanied in every instance by the deposition, in most cases to a very striking degree, of doubly refracting material giving the staining reaction of fat." Glomerular changes were also present in every case. In those cases where edema and albuminuria were the most marked clinical manifestations, the kidneys at autopsy showed no evidence of inflammation of the glomeruli, but degeneration of these renal units was evidenced by loss of differentiation of the loops of the tuft, increase or disappearance of the nuclei, and alterations in their staining properties, those of all glomeruli being alike. Other patients, beside exhibiting edema and albuminuria, had macroscopic hematuria as well, and at autopsy their kidneys showed gross alterations of the glomeruli as well as the more common tubular changes. In two subjects these glomerular changes were definitely inflammatory, and in one there was ' amyloid change,' but in all there was definite morphological alteration of the glomeruli. During life all these last-mentioned patients showed an increasing tendency toward failure to excrete urea, and a slow but progressive rise in blood pressure. Elwyn found lipoid nephrosis was always preceded by diffuse glomerulo-nephritis, all forms of which were characterized by a marked contraction of the small arteries and precapillary arterioles. In the subchronic and chronic forms this arterial contraction may exist for years, and it is reasonable to suppose that this might bring about disturbances of intracellular mechanism which persist after a diffuse acute nephritis has subsided. As an example he cites persistent albuminuria, which may either be constant, or only detectable after some slight infection or unusual exercise had increased the burden upon previously crippled glomerular capillaries and capsular epithelium. In like manner, eclampsia, or a milder renal disturbance during pregnancy, wherein arterial contraction is generally recognized as a factor in the pathogenesis, may be attended by a most persistent albuminuria, indicating a permanent effect from the injury sustained by the renal units during the acute phase of the disease.

It was noted by McElroy that true uremia is not present in lipoid nephrosis, and though eclamptic attacks have been reported, they are rare. Anemia is not usually a complication and the blood volume is normal, though with a total protein blood content that is noticeably low. There is a displacement of the protein blood picture to the gross disperse side, the fibrinogen often being nine times the normal, and the globulin four times normal. Hypercholesterolemia is in evidence and the sedimentation velocity increased. During the elimination of edema there may be an increase of nonprotein nitrogen in the blood, but otherwise this is not noted in uncomplicated cases. The water and concentration tests are likely to be normal.

One of the best discussions of this particular form of renal disease which has come to my attention is that given by Warfield and Murphy before the Association of American Physicians in 1926. They briefly reviewed the work done by Munk in Germany and Epstein in this country, and came to the conclusion that these investigators were dealing with precisely the same condition. Had Munk examined the blood as Epstein did, thus being led to lay stress upon the decrease in the plasma proteins and the reversal of the albumino-globulin ratio in the blood; and had Epstein examined the urine for the doubly refracting lipoids which to Munk were the outstanding feature, each would probably have made findings identical with those of the other.

Treatment. Dietary treatment has so far offered the best hope of combatting lipoid nephrosis. Epstein recommended a very high protein diet such as is supplied by lean veal and ham, egg-white, oysters, gelatin, mushrooms and bananas; dehydrated vegetables as lima beans, lentils and split peas; cereals such as rice and oatmeal; skimmed milk, tea, coffee and cocoa without cream. Most meats and fish, if lean and unsalted, will have a place in this dietary. Thyroid extract in gradually increasing doses has been used by some experimenters, but the results are not yet sufficiently standardized to permit such treatment being unreservedly recommended. Edema may be eliminated by the customary measures, water and salt limitation, and the exhibition of diuretics. It is suggested by Bennett and his coworkers that the administration of urea by mouth would be a rational therapeutic procedure, if blood analyses at repeated intervals shows that there is no nitrogen retention.

Prognosis. The particular form of kidney disturbance now recognized under the name *lipoid nephrosis*, taken by itself, offers a favorable prognosis. Of the reported " fatal cases " many died of an intervening peritonitis or a terminal pneumonia, and the general lowering of vitality inherent in such a condition doubtless makes its subjects an easy prey to any infections with which they may happen to come in contact. The very fact that the disease is extremely chronic and subject to extended remissions makes its control more difficult, and continued observation hard to obtain.

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III

INFECTIONS OF THE KIDNEY

The subject of renal infection is far too wide to be adequately discussed in a single chapter. I shall therefore exclude several aspects of the subject which will be found treated under other headings — renal tuberculosis for example. There is a large group of infections of the kidney secondary to some other renal or urinary tract disease, or dependent upon some structural anomaly, which are discussed under the headings appropriate to these various conditions, so that they may very well be omitted here.

After making these exclusions there remain a considerable group of kidney infections which for want of a more exact term, may be designated as *primary*. Regarded clinically they fall naturally into two groups; those located in the kidney cortex and those affecting the pelvis especially. The chief representative of the first type of infection is that producing perinephritic abscess, and lesser abscess conditions of the cortex, most commonly of staphylococcic origin. In the second group we may place the very common conditions of pyelitis and pyelonephritis, of which the colon bacillus is most often the causative organism.

INFECTIONS OF THE CORTEX

Renal carbuncle. As already stated, in the majority of instances infections of the renal cortex are of staphylococcic origin. Though termed ‘primary’ above this type of infection is almost always secondary to a focus elsewhere in the body. Metastasis from a carbuncle upon the neck to what has lately become known as *carbuncle of the kidney* is probably a not uncommon occurrence, as was ably demonstrated by Mathé not long ago. The lesion is defined by this author as a circumscribed infectious inflammation, with the formation of multiple foci of necrosis, often ending in a suppurating slough. It should not be confused with single or multiple renal abscesses, nor with acute septic infarct — a condition in which the kidney is studded with multiple minute abscesses. The carbuncle usually develops in the renal cortex, adjacent to the capsule. There is a large central abscess — which gradually increases in size — surrounded by smaller sized abscesses. Eventually all coalesce to produce a single confluent lesion.

Occurrence. The term ‘ renal carbuncle ’ apparently originated with Israel of Berlin many years ago, although some very eminent urologists have given the credit for coining the name to Brewer of New York at a much later date. The close resemblance of this renal lesion to carbuncle upon the skin, and the undoubted relationship which it bears to cutaneous pus collections of this type, makes the name a fitting one. It is probably of much more frequent occurrence than is generally recognized. This accounts for the relatively few cases which have been reported in literature. Kretschmer in this country, collected only a small number, to which he added two of his own. Mathé, a little later collected a few more, so that including his personal case he was able to tabulate 22 cases. Of these 16 were in males and 6 in females; 11 lesions were in the right kidney, 8 in the left kidney, 2 were bilateral, and in one case the side of location was not mentioned. Fifteen of the patients were in the third and fourth decades of life. As the age was not stated in four cases, it is evident that renal carbuncle is an infection of early adult life, and the preponderance of male patients would seem to indicate that occupational trauma and exposure may be in some degree related to it. As skin infections are so common, it seems odd that metastasis to the kidney occurs so seldom. The inference is not unreasonable that the localization of the lesion in the kidney only takes place when some previous injury, traumatic or otherwise, has rendered this organ in some way peculiarly susceptible to such invasion. This would also account for the fact that the majority of cases are unilateral. In a blood-borne infection it would seem likely that bilateral invasion would be the rule. A lowered resistance in a single kidney might account for localization in that particular organ.

Symptoms. The symptoms are those of the presence of an acute inflammatory process in any part of the body. They are usually severe, the temperature in particular, being always elevated. In one of Kretschmer's cases it reached 104.6° F. Symptoms referable to the kidney are often slight, or wholly absent. There may be pain in the lumbar area or even a palpable tumor in the region of the affected kidney, but more often even the most acute manifestations do not appear to bear any relation to the urinary tract.

Diagnosis. The history of a preceding furunculosis or carbuncle will, of course, be suggestive, but as in many cases this has been regarded so lightly by the patient as to be omitted in giving the history, and may have occurred so long before as to have been totally forgotten. Renal roentgenography will usually reveal the presence of a well advanced carbuncle, but is not much assistance in the very early stages. The indications are so similar to perinephritic abscess that the two conditions are seldom differentiated previous to operation. This is peculiarly unfortunate as early recognition would undoubtedly permit many kidneys to be saved which are so nearly destroyed before remedial measures can be applied that nephrectomy is the only possible course. It is well to bear in mind, as Mathé cautions, that even when one comes upon a perinephritic abscess, this may have had its origin in a renal carbuncle. In all the cases reported which terminated satisfactorily nephrectomy was employed. This is applicable, naturally, only to unilateral cases. Where the carbuncle has progressed so far as to have broken down, Kretschmer remarks that the institution of drainage is an easy matter. The fact remains, unfortunately, that by that time, neither drainage nor any other measure, is likely to avail to prevent a fatal termination. If one is so fortunate as to recognize a renal carbuncle still in its early stages, there is a fair possibility of instituting drainage and preserving a useful kidney, but in actual practice this seldom occurs.

Perinephritic abscess. In his recently published *Chirurgie de Rein* Papin differentiates three forms of perirenal suppuration: (1) Epinephritis — inflammation of the capsule proper: (2) perinephritis — inflammation of the adipose tissue, that is, perinephritic abscess properly so called; and (3) paranephritis — retro-renal suppuration beyond Zuckerkandl's fascia, or prerenal suppuration between the prerenal fascia and the peritoneum. In general, it may be said that perinephritic suppuration results from an extension to the perirenal fat of a pyelitis or other infectious process within the kidney. The intrarenal condition may result from calculus, or some such infection as tuberculosis. Less often it is a secondary process dependent upon an original focus in some other part of the body.

Etiology. There are three possible ways by which infection may be conveyed to the perirenal fat; first by way of the lymphatics; second, by metastasis through a blood-borne infection; and third, from some unrecognized renal infecton. Lowered resistance through trauma or similar factors probably plays a rôle here, just as in carbuncle of the kidney.

The likelihood of lymphatic origin is obvious. The cortex has communication with the lymph-vessels of the perinephric fat by passage through the fibrous capsule of the kidney. Likewise many other connections exist through the iliac, lumbar and hypogastric nodes; between the lymphatics of the perinephric fat and those of the diaphragm; and also by intercommunication of the lymph channels of ureter, kidney and bladder. Any of these routes might serve to convey infection from some

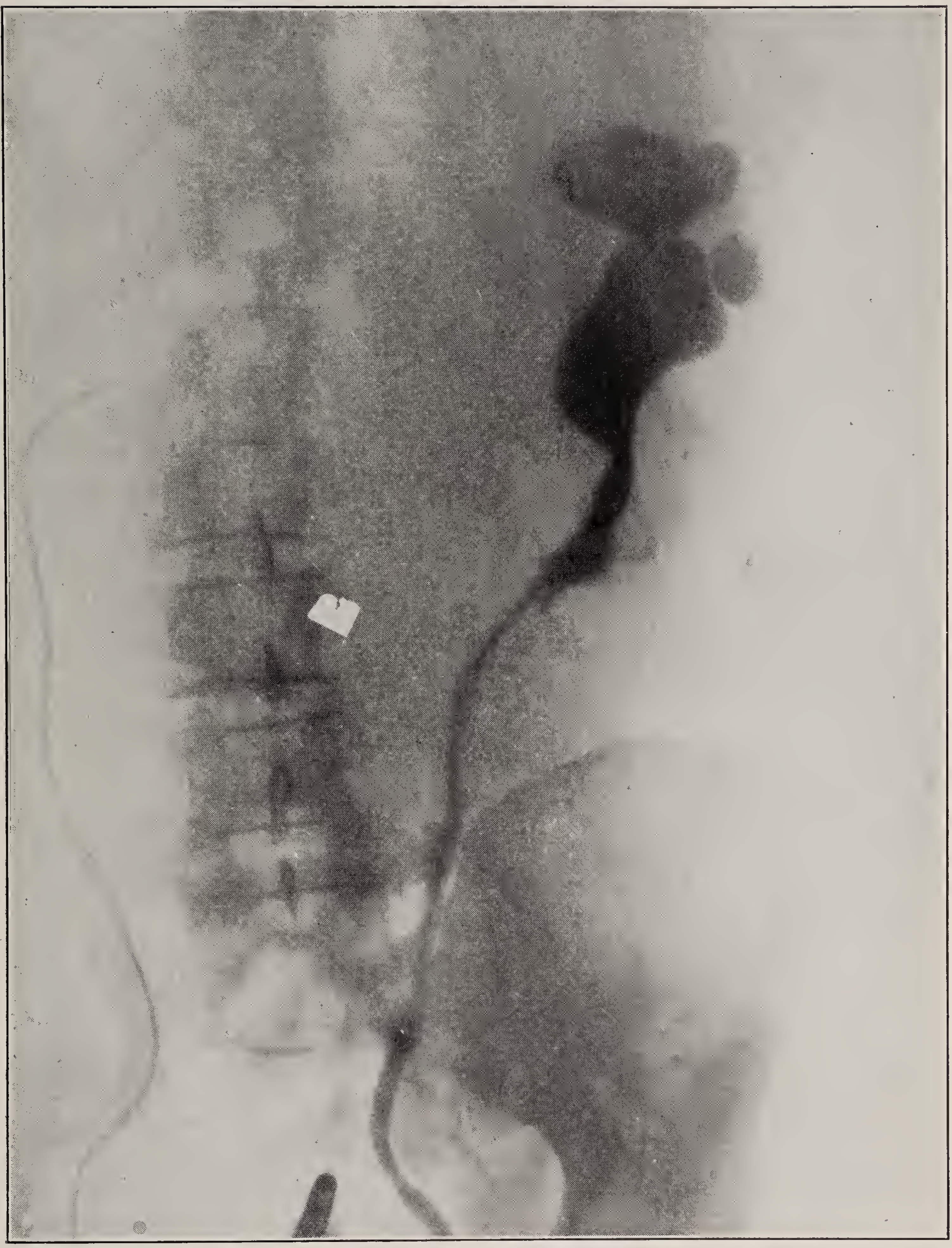

FIG. XXXVII. Perinephritic abscess extending from renal cortex to the pelvis.

relatively distant source. Also metastatic infection can very well take place directly through the vessels of the fatty capsule, or by hemogenous infection from suppuration within this capsule. Lesions in the renal cortex or fibrous capsule may rupture directly into the perirenal fat.

Hematogenous infection is probably the most common cause of perinephritic abscess. In the 108 cases found by Richardson in the literature which were reported as due to metastatic infection, 9 had an abscess limited to the renal cortex; in 24 the perinephritic suppuration was apparently an extension of a cortical abscess; while in the remainder the operation did not reveal the source of suppuration. In these cases 55 had the perirenal suppuration preceded by furuncles; 21 patients had suffered previous paronychiæ or septic fingers; there were 10 histories of carbuncle, 11 of local abscesses variously located, 3 of tonsillitis and three of septic wounds. In 31 cases the infecting organism was the staphylococcus alone, and it occurred many more times in combination with other organisms. In the 34 cases of ‘ primary ’ perirenal suppuration of Richardson’s own series, he felt there was very little evidence to show that it was due to metastatic hematogenous infection. The fact that the urine is normal on clinical examination does not at all preclude the possibility of cortical renal abscess, suggested by clinical symptoms.

Symptoms and diagnosis. The blood count is of great importance in establishing the diagnosis of perinephritic suppuration. It may give evidence before there is much rise in temperature, or the characteristic chills, tenderness to palpation and pain in the renal region. The pain though usually intense, is very often deceptive in that it is likely to be referred to the thigh or the scrotum. Indeed the complaints of distress in the hip may mislead the examiner for a considerable period, and the existence of perirenal suppuration not be suspected until it has progressed to the stage of fluctuation of pus in the loin.

Treatment. If left untreated a perinephritic pus collection will usually work its way to the surface, leaving a discharging fistula which is peculiarly resistant to treatment, in those patients who escape immediate death from peritonitis. Surgical evacuation, if applied early enough, is fairly satisfactory, and has resulted in a good percentage of cures. The condition must always be regarded as an extremely grave one, requiring not only skilful surgery, but a continuous watchful course of supportive measures, best extended over a long time, as these patients are usually greatly depleted systemically, and likely to have to undergo prolonged convalescence.

Minor cortical suppuration. It was not long ago pointed out by Cabot that in addition to the ‘ spectacular ’ manifestations of renal and perirenal suppuration just discussed, many cases are encountered in routine practice which are undoubtedly of the same general nature, but never reach the fulminating stage and are overlooked in consequence. Many times following some cutaneous or similar infection, an individual will complain of pain in the renal area, and upon examination will display tenderness to palpation, and probably some rise in temperature. If the urine of such a patient be examined at this time, one is likely to find therein the organism responsible for the preceding or concurrent peripheral lesion. He believes that we may in this way account for the scars upon otherwise healthy kidneys not infrequently seen at autopsy. Infection undoubtedly takes place but never becomes acute enough to produce marked symptoms of its existence. The suppurative process is self-limited and recovery takes place spontaneously.

Pelvic infections. The designations *pyelitis*, *pyelonephritis* and *pyonephrosis* are employed to indicate different degrees of the same condition. Pyelitis is an infection confined to the renal pelvis and calyces; pyelonephritis indicates a condition wherein the parenchyma, that is, the kidney proper, is likewise involved; while by pyonephrosis is meant an advanced condition of suppuration, often reducing the kidney to a mere pus-filled shell. Any of these states may be acute or chronic, or less often, of a fulminating type. The common symptom which shows their close relationship is the finding of pus and organisms in the urine. These may be so abundant as to be perfectly evident to the patient himself; again only a skilled microscopist will be able to detect them. Frequency and dysuria are common complaints, and less often are we told of the pain in the back, which has been made familiar to generations of laymen by copious advertising illustrations.

Sex incidence. One of the most striking characteristics of this group of renal infections, marking it off from that previously discussed, is the great preponderance of female over male cases. Even omitting the pyelitis of pregnancy, there still remains the pyelitis of childhood, the victims of which are practically all girls, and in the adult cases having no relation to pregnancy, females still greatly outnumber males. The reason for this sex difference has been very diligently sought, but no adequate explanation has ever come to my attention.

Diagnosis. Presented with a case of kidney infection the examiner will first attempt to ascertain the origin of the infection; next whether it is bilateral or confined to one side only; following this he will apply tests of renal function and make efforts to ascertain the degree of renal destruction brought about by the infection; and finally, endeavor to demonstrate the existence of predisposing factors, such as renal calculus, congenital anomaly, tumor, and so on, to which the pyelitis may be secondary.

Examination of the urine is regularly the initial procedure. The causal organism most often found is the colon bacillus. This is in evidence in about 90 per cent. of cases, according to some authors. Others place it between 70 and 80 per cent. All agree unreservedly that it is overwhelmingly the most common. As the colon bacillus is a normal inhabitant of the intestine it is argued that intestinal stasis, with subsequent absorption of these organisms into the blood stream, is the mode of infection in most cases. A further indication of the correctness of this theory is the very beneficial effect which adequate colonic therapy has upon infected kidneys. This connection cannot be regarded as fully demonstrated, but it certainly offers suggestive evidence.

With the diagnosis established, the next step should be to exclude the existence of such causative factors as renal or ureteral calculus, which is readily accomplished by X-ray examination of the urinary tract. The bladder is then examined with the cystoscope to determine the presence or absence of vesical lesions such as tumor or diverticulum, and to locate and examine the ureteral orifices, the appearance of which may give some clue to the source of pus and organisms. Tests of renal function, collection of specimens of catheterized urine from each side, and the passage of catheters to the renal pelves, follow in order until by process of exclusion the lesion is located in the renal pelvis. Pyelography may have to be called upon, but in most cases the diagnosis may be established without it, and its unnecessary use is to be deprecated. It is important to emphasize, that we should not be content merely by determining pus in the urine, and instituting a course of renal lavage or oral medication before we have positively excluded the many grave conditions which early evidence themselves by symptoms closely resembling those of primary pelvic infection.

In pyelonephritis and pyonephrosis the evidence offered by pyelography will be indispensable. The pyelogram of a normal calyx shows it regularly cup-shaped. In pyelonephritis it will be clubbed and knobby; while the pyonephrotic kidney shows up as a deep irregular enlargement of the shadow, not only of the pelvis and calyces, but of the kidney as a whole.

Elimination of focal infection. The experiments of Rosenow showed a very definite connection between focal infection in the head and calculus disease of the kidney. In like manner it seems highly probable that many cases of pyelitis owe their origin to such focal infections. Therefore, the first step in the therapy should be a search for such infective foci, and their immediate elimination if found. Particularly is this true of the pyelitis of pregnancy. Hugh Cabot, to be sure, rejects the theory of focal infection as having any bearing upon the production of pregnancy pyelitis, or any other. It is his belief that the greater prevalence of pyelitis in females may be explained by the greater likelihood of females to renal and ureteral retention, and puts forward what he terms the " doctrine of the prepared soil " to account for the pyelitis of pregnancy, wherein conditions favoring retention are unquestionably present. He admits that this does not explain the numerous cases of pyelitis in little girls, so his theory, like that of his predecessors, must be marked ' unsubstantiated ' at present.

Treatment. The treatment of renal infections depending upon some definite lesion or abnormality must, of course, be in conjunction with that cause. There remain to be dealt with those infections which cannot be proved dependent upon urinary retention due to ureteral or vesical pathology, or otherwise traced to any definite lesion of the urinary tract. In most cases resort must be had to medical measures, lavage with suitable antiseptics; oral administration of drugs to change the reaction of the urine, and measures to promote free drainage, chief among which is the use of the indwelling catheter. For pelvic lavage the silver solutions — silver nitrate in solutions varying in strength from 1 : 100 to 1 : 500 most commonly — still hold general favor. Mercurochrome has been much advocated, but its popularity is waning at present. Acriflavine and aluminum acetate are also considerably employed.

Drugs by mouth. As the colon bacillus is the culprit in most cases, the drugs administered orally should be directed especially toward the extermination of this particular organism. Bringing about a change in the reaction of the urine is more effective upon the colon bacillus than upon the less prevalent organisms of the staphylococcus or streptococcus groups. Helmholtz has shown that we can reach more of the seventy-odd strains of colon bacilli by rendering the urine alkaline, than by the employment of agents which make it acid. The best routine is to follow the administration of alkalies for a given period, and then resort to acids for a similar length of time. An abundance of alkaline or plain water should be taken throughout.

The use of urinary antiseptics by mouth has long been a general practice and needs but little comment here. The perfect urinary antiseptic still awaits discovery. Hexamethylenamin has been in use for a long time now, and though it is by no means wholly satisfactory, none of the newer preparations put forward to supersede it, have proved able to do so.

Kidney infections are among the most perplexing urogenital conditions brought to the practitioner's attention. The diagnosis is always attended with more or less confusion, and the symptoms are so vague and so likely to be manifestations of a far graver condition that the responsibility placed upon the diagnostician is a heavy one. Thorough examination and the employment of all the means which he can command which help to clarify the situation are his only safeguard. And once the diagnosis is established, patience and unremitting attention will be essential to final success.

VENEREAL INFECTIONS

Gonorrhea of the kidney. That gonococcal infection of the kidney is rare may be surmised from the recent publication of Birkhaug and Parlow. These authors collected but 32 cases reported in literature and all but four of these they considered doubtful, inasmuch as no fermentation or serological reactions had been obtained in diagnosing them. It may be remarked that in some of these cases the laboratory methods now at our command had not been introduced at the time they were reported. Mixed infections are, of course, very common in all types of renal disease, and in most instances it would be difficult to isolate the gonococcus and assert positively that it alone was responsible for a renal infection.

Inasmuch as gonococcal infection is exceedingly common, and renal gonorrhea so rare, it seems reasonable to suppose that the epithelium of the ureter and kidney pelvis is of a type unfavorable to the growth of this particular organism. Kemble suggests that as it has long been known that prolonged treatment of the urethra often brings about a change of its normal columnar type of epithelium to a flatter type, comparatively immune to future attacks of the gonococcus, nature may have established a similar immunity in the upper urinary tract. The pelvis seems to be the only portion of the kidney invaded.

Gonococcic infection is in all probability blood-borne in all renal cases. The theory of ascending infection has been pretty well discarded in most cases of renal infection, although the experimental demonstration of the possibility of regurgitation from the bladder has done something to strengthen the position of those who adhere to it. In most of the reports, the kidney infection appeared to be a metastatic invasion similar in nature to gonorrheal arthritis or any other hemogenetic complication. Kemble's patient denied all venereal infection though a member of her family was at that time under treatment for a gonorrheal vaginal discharge. Specimens obtained from the left kidney by ureteral catheterization showed abundant gonococci under all methods of examination. Bacillus coli were found on both sides. Pelvic lavage was the only treatment permitted by the patient, who passed from observation before the course could be properly completed. Birkhaug and Parlow's patient had a history of gonorrheal vulvo-vaginitis and secondary syphilis previous to the diagnosis of gonorrheal pyelitis. The right kidney urine was very turbid, and the organism was positively identified in it. There was no dye excretion from this side at the end of thirty minutes, and the pyelographic examination disclosed a stricture at the uretero-pelvic junction which had caused a pyonephrosis. The kidney was removed and the pus within the pelvis showed an abundance of Gram-negative diplococci, arranged both intracellularly and extracellularly. No other organisms were isolated. Later urinalysis and examination of smears showed no trace of the gonococcus.

Diagnosis and treatment. The methods of examination employed for the determination of Neisserian infection of the kidney are the same as that for other types of infection. Previous discovery of the organism will naturally point out the possibility of its etiologic significance in relation to the renal lesion. The direct smear is not sufficiently positive; the serological reactions are the most reliable if it is possible to employ them. Where it is not possible, cultural and fermentation reactions can usually be relied on to establish the identity of the organism.

Treatment will depend upon the stage of the infectious process at which it is instituted. In less virulent cases pelvic lavage will usually suffice to bring about a cure. If the kidney has already suffered damage, as from congenital stricture as in one of the cases cited, the addition of the gonococcal infection will probably destroy whatever usefulness the organ possessed before, and nephrectomy will be the only possible course.

Syphilitic nephritis. Though syphilis of the kidneys was recognized and studied as far back as the time of Alfred Fournier, reports of this condition are seen but seldom in present-day literature, and the impression remains that it is decidedly uncommon. Yet it is very probable that the observation of Hess that it is not so uncommon as unrecognized reveals the true situation. Syphilitic nephritis is regularly seen by the general practitioner, seldom by the urologist or syphilologist. Many fatal cases of acute nephritis may pass unrecognized as being of luetic origin, for many difficulties attend the recognition of this fact.

Two predominant characteristics were postulated by Fournier, as distinguishing syphilitic nephritis from that due to any other cause: The immense amount of albumin present in the urine and the rapid onset and early tendency toward uremia. The diagnosis would be suggested by a definite history of a primary luetic infection; the appearance of nephritis in, at, or just before secondary manifestation of the luetic infection set in; and the elimination of all other causal factors.

Symptoms. The symptoms of nephritis in the second stage of syphilis do not differ from those of nephritis due to other causes. There is seldom any headache, but pains in the back and more or less edema of the tissue is the rule. A tendency toward early uremia, as noted by Fournier, is common. The one marked variation from the normal is the albuminuria, which is always marked. Casts of different varieties may be present, yet renal permeability is rarely impaired. The phenolsulphonaphthalein test usually gives practically normal returns, even when clinical signs point to extensive renal impairment. Just what the pathological changes brought about by the invasion of the *Spirochaeta pallida* are is difficult to find out, inasmuch as few autopsy reports are available, the condition being rarely or never fatal. Dowling describes the condition as an allergic phenomenon, the intensity of the reaction of the kidney being part of the supersensitive state of the patient's tissues at this stage of syphilis, which is well illustrated by the exanthematous response of the skin.

The indications of late syphilitic nephritis are much less positive. A patient seen by Dowling had suffered from ' chronic Bright's disease ' for almost five years before a tertiary syphilitic ulceration of the soft palate appeared, and the possibly luetic origin of his kidney condition was for the first time suspected. This author notes the following characteristic features of late syphilitic nephritis: The disease runs a protracted course with no tendency to spontaneous resolution, and little or no tendency to improve when the patient is placed under the ordinary treatment for nephritis. The albuminuria is excessive, judged by the standard of nephritis as commonly encountered. The course of the disease is relatively benign, in that vascular changes either do not occur at all, or make their appearance very late, for in spite of the urinary symptoms blood pressure remains low or very near normal. The most striking feature of all types of syphilitic nephritis is the almost magical response to antiluetic treatment. Once the correct diagnosis has been made and proper therapeutic measures put in practice, control of symptoms promptly follows.

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IV

RENAL TUBERCULOSIS

THERE is now a very general recognition of the fact that renal tuberculosis is relatively common. Primary tuberculosis of the kidney is still regarded as rare. The difficulty in positively demonstrating it to be primary permits this belief to go largely unchallenged. My personal experience has led me to believe that it is not so much renal tuberculosis that is rare, as the ability to diagnose it properly. The specializing urologist sees many cases which are sent to him in the belief that the patient is suffering from some other lesion of the urogenital tract, more often than not something implicating some organ other than the kidney. Eberbach tells of a patient received at the Urologic Clinic of the Michigan University Hospital with a diagnosis of empyema. Examination showed the existence of a tuberculous perinephritic abscess which had ruptured opposite the ninth rib in the midaxillary line, this fluid collection leading to the diagnosis. Such a ' far-fetched ' diagnosis is perhaps unusual, but mistakes are exceedingly common, and all too often fraught with grave consequences to the patient.

The accuracy of what statistics we have regarding the prevalence of renal tuberculosis may well be questioned. Ten thousand case records in some of the great sanatoria in Colorado were gone over by H. H. Young, and among all this number he found but 65 recorded instances of urogenital tuberculosis, of which 50 were of the seminal tract and only 17 noted as confined to the kidney alone. He believes that any ratios compiled from such a series would be highly misleading, his personal reason being that when renal tuberculosis is diagnosed, the patient is kept at home for operation, rather than sent west for climatic treatment. There is more than a suspicion that other factors may have an influence here. There are assuredly many cases of renal involvement in subjects of other forms of tuberculosis which are overshadowed by the importance of the extrarenal lesions. Yet it is within the bounds of possibility that the focus in the kidney may have been the first site of infection.

Diagnosis. A great deal of practical information as to the diagnosis and clinical course of tuberculosis of the kidney has been put at our disposal by Thomas and Kinsella of Minnesota. At the Glen Lake Sanatorium where their observations were made, unusual advantages for the carrying out of such work are offered, not the least of these being the possibility of watching the individual cases over a long period of time. There is also an excellent opportunity to detect incipient cases before they progress to the advanced stages which are only too frequently the only ones seen by the examining physician in routine practice outside of institutions.

In their opinion, every individual who carries a tuberculous lesion anywhere in his body is a ‘ candidate ’ for renal tuberculosis. Moreover, a patient may have an active renal tuberculosis yet present no bladder irritability or other characteristic evidences. When the existence of a tuberculous focus other than the kidney has been established, the urine should always be kept under surveillance. The detection of cellular elements in the urine should at once put the examiner on his guard, and no time should be lost in making careful and repeated urologic study. But even if such cellular elements and tubercle bacilli likewise, are found in the urine, a pyelogram will frequently fail to reveal any destructive lesion in the implicated kidney. Such symptoms may later clear up, the urine become negative and no further evidence of renal involvement be detected for years. If symptoms do recur it is thought to be either because the patient has contracted a second kidney infection through the bloodstream from an extra-urinary focus, or because an old quiescent lesion has been for some reason reactivated. The diagnosis of the early or non-destructive lesion in renal tuberculosis often cannot be made at all. The active stage may be brief and the lesions so small and so quickly healed that they cannot be detected. If tuberculous lesions elsewhere in the body are not arrested, such a healed renal tuberculosis will very often, given the proper conditions, become active after a long period of quiescence.

Another valuable observation made by these investigators was that patients who on entrance to the Sanatorium showed gross lesions of renal tuberculosis by pyelography, improved greatly under the general “ rest cure ” afforded by the institutional regime, without any special attention to the kidney condition. The urine which at entrance was heavy with pus, leukocytes and albumin, after a year or more of sanatorium residence, was negative even to guinea-pig inoculation. Not all sufferers from renal tuberculosis possess or develop sufficient resistance to their general tuberculous infection to accomplish this. Quite as often the kidney will be rapidly destroyed, and it is likely that the extra-renal lesions will follow the same course, with an eventual fatal termination. Only when the patient gives evidence of possessing a certain amount of resistance to the invasion of the tubercle bacillus is it advisable, in the opinion of these authors, to perform nephrectomy, even when there is no question about the immunity and functional ability of the other kidney.

Classification of kidney infection. Tuberculosis when located in the kidney manifests itself in either of two ways, generally designated as 'closed' and 'open.' To these may be added a third form, less often seen, at least in this country, which by the Germans is called *Nephrocirrhosis Koch-bacillaris*, that is, tuberculous sclerosis of the kidney.

'Closed' renal tuberculosis. It is doubtless correct to state that at the outset every tuberculous lesion of the kidney is 'closed.' It is only when the process has had sufficient time to extend into the avenues by which urine escapes from the kidney that its evidences will be conveyed to the lower portion of the urinary tract. Again, obstruction of the ureter may occur very early, and this will close off completely the escape of incriminating evidence into the bladder. Not infrequently all the calyces will be involved without any lesions being sustained by the pelvis, which will keep the lower urinary tract wholly free from infection. The kidney will soon be destroyed, especially if there be ureteral obstruction, and the final result will be either a pyonephrosis or what is termed a 'putty kidney,' in which the caseating process common to tuberculous lesions in any part of the body, entirely replaces the renal parenchyma.

'Open' renal tuberculosis. As the majority of tuberculous renal infections begin in the immediate vicinity of the pelvis, the 'closed' form must be regarded as relatively uncommon, and, therefore, likely to complicate diagnosis when it does make itself manifest. The original lesion is most often close to the tip of a papilla, so that it early infiltrates the neighboring calyx. There are undoubtedly many lesions which take their rise far down in the renal tissue, and must, therefore, attain a considerable size before they reach the pelvis by extension. Once the process has attained the renal pelvis, its progress is likely to be much more rapid, the adjoining collecting tubules being quickly involved. The fibrous capsule next becomes implicated, and later the renal fat capsule. Thence arise the numerous adhesions which so greatly hinder the surgeon seeking to free a tuberculous kidney before nephrectomy. This, too, is often followed by tuberculous perinephritic abscess. Calcification is common, though by no means universal. Perhaps a quarter of the cases subjected to roentgenographic examination will be sufficiently calcified to be opaque to the rays and permit recognition of the lesions upon the X-ray film.

Involvement of the ureter occurs relatively early, and the changes which pyelography will show in its duct are often our best guide to the condition of the kidney. Once the bladder is invaded, we are presented with tuberculous cystitis, probably the lesion most often causing the patient to seek medical advice. Diagnosis which has evaded early search will be easily established once the characteristic appearance has been assumed by the ureteral mouths and the vesical mucosa.

Sclerotic tuberculous kidney. In the third and rarer form of kidney tuberculosis, the organ does not show gross lesions when exposed, only its size is markedly reduced. Microscopic examination will show tubercle bacilli in the tissues, and the urinary tract lower down will give a typical picture of tuberculous invasion.

Pyelographic diagnosis. The wisdom and advantages of using pyelography in the diagnosis of renal tuberculosis is still a matter much discussed, and upon which no definite conclusions have yet been postulated. Kearns a few years ago discussed the question at length before the Radiological Society of North America, cited a large number of opinions both for and against, and ended by saying that he never employed the method in his own practice, preferring to depend upon clinical signs and the results of bacteriology. The many pyelograms which he showed had all been made from freshly excised specimens injected with opaque media, which he had obtained immediately after nephrectomy had been performed. There is no doubt that some danger attends injection of the tuberculous kidney, yet it has been done without detriment to the patient in many hundreds of cases. Stevens has pointed out the valuable aid which plain roentgenograms often give, and urges the more frequent and intelligent employment of this in the diagnosis of suspected renal tuberculosis.

Functional tests are recommended by many foreign writers, notably Wildbolz, Marion and Legueu. Wildbolz uses cryoscopy or indigo carmine, and declares that the presence of a renal tuberculosis involving one or both sides can only be established or denied by the employment of functional tests of some kind. Unless there is decrease in function also, the mere presence of pus or even a few tubercle bacilli in the urine, does not always mean that the kidney is infected with tuberculosis. Stevens himself has on more than one occasion seen an increase of function in a tuberculous kidney, so proved later by bacteriologic examination of the excised specimen. He has found the subcutaneous injection of tuberculin useful when the result was positive, but attaches no value to negative results. If there is a rise in temperature, accompanied by focal reaction such as increased pain in the kidney region, more frequent urination and more pus and tubercle bacilli in the urine, he regards the indications as highly significant. In cases where bilateral infection is suspected, or actually present, this procedure has especial usefulness.

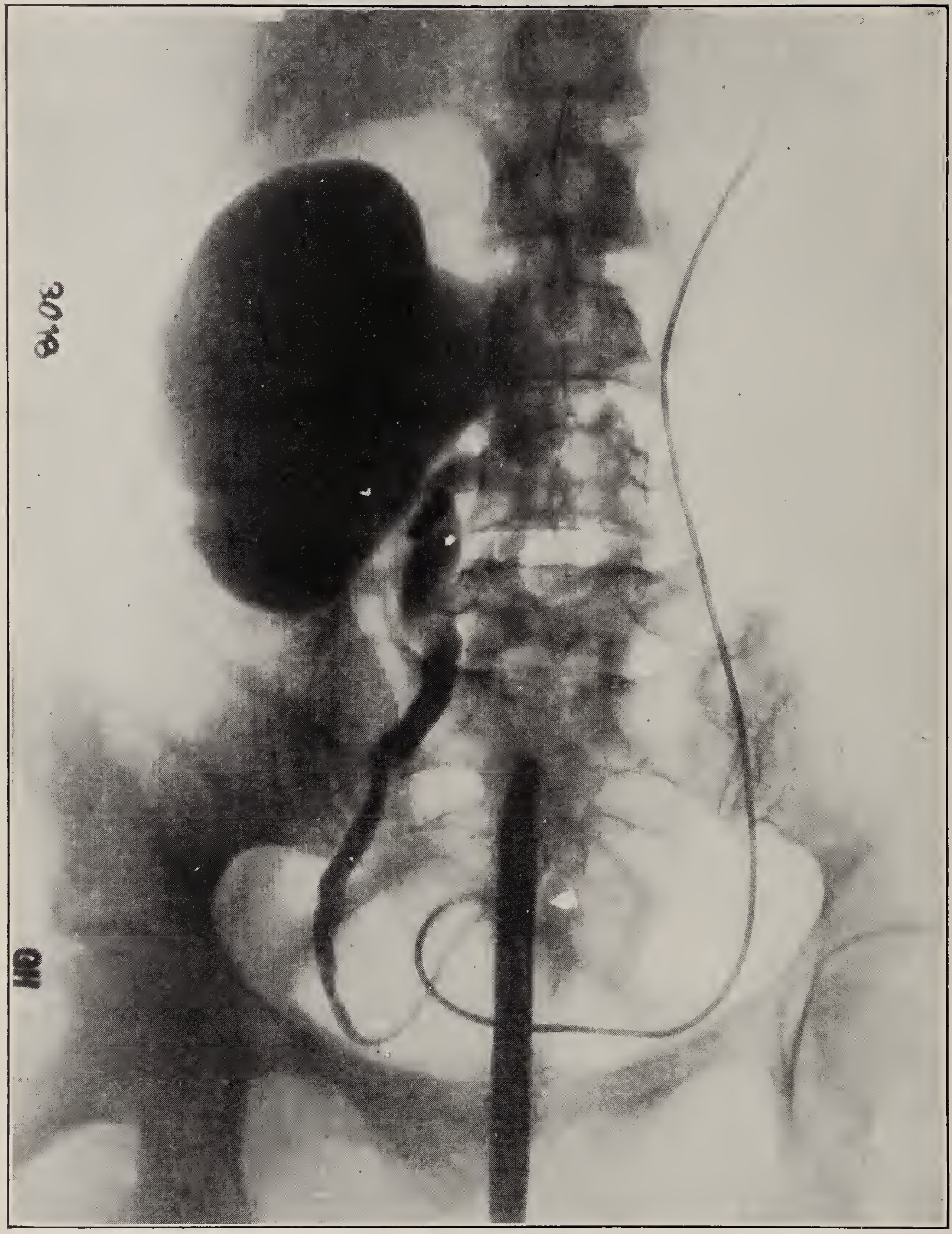

FIG. XXXVIII. Pyeloureterogram showing the rapidly developing type of renal tuberculosis. Marked distortion of the ureter.

Heliotherapy. Rollier, whose name is inseparably associated with heliotherapy as practiced in the High Alps, urges the use of sunlight treatment in all stages of renal tuberculosis. Where cystitis is extreme, heliotherapy applied to the kidneys, or rather to the entire body, will be an excellent preparation for subsequent operation, or for cystoscopy in those patients who are unable to bear instrumentation in any form. His experience has been that under the influence of sunlight the trouble becomes more chronic; a careful sun cure is of much value while waiting for an inflamed bladder or prostate to quiet down. It is a factor influencing the renal process and reducing the probability of bladder complications until such time as cystoscopy can be practiced with impunity. Bilateral renal tuberculosis is often most favorably influenced, although it is impossible to produce figures confirming this impression. Many patients have so improved they could go to work once more; the purulent sediment in the urine grew less; micturition was less frequent; and body weight markedly increased. For the prevention of secondary lesions lower down in the male genital tract especially, sunlight treatment is strongly to be recommended, and can be profitably employed after the removal of a tuberculous kidney.

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V

RENAL CALCULUS

Etiology. One of the most frequent calls upon the renal surgeon is to search for and remove stones from the kidney. It is probable that the majority of urinary calculi originate in the kidney. Just what factors operate to produce stone is a matter of dispute, and none of the theories so far put forward have been entirely substantiated. Just at present the one most generally accepted is the theory of focal infection. This was put forward by Rosenow of the Mayo Clinic several years ago, and has since been championed by many urologists and bacteriologists. Infected material from human kidneys containing stones, and also from the teeth of individuals suffering from nephrolithiasis, was placed in the teeth of dogs. In a comparatively short time these animals developed stone formation in the kidney, which seemed to indicate that the occurrence of renal calculi is dependent upon some kind of focal infection, probably streptococcic in most cases.

The idea that climate and water supply have great etiologic significance in the occurrence of stone has been prevalent for many centuries. This is not incompatible with Rosenow's findings, for it is quite possible that in some localities the infective agents might be more prevalent than in others. It has been noted that the inhabitants of hot countries, or especially humid regions such as are found extensively in China, suffer greatly from stone. This has led to a belief that high concentration of the urine, due to the elimination of water through the skin rather than the kidneys, may play an important part. The mineral content of the water and food stuffs of various races have been carefully examined with a view to ascertaining whether this is of importance in stone formation. Many investigators have felt that the evidence was conclusively in favor of a high mineral intake being responsible for calculus disease. On the whole, none of these explanations can be stretched to cover all cases, and we are still considerably in the dark as to the etiology of renal calculus.

Diagnosis. The first application of roentgenography to urology was in the diagnosis of calculi. Today the X-ray is still our main aid to diagnosis, and with the constant improvements in technique the detection of these concretions has steadily advanced in ease and accuracy. The chemical composition of stones varies so greatly that there can be no standardization of roentgenographic results. Calcium oxalate and calcium sulphate give very good shadows, due to the high anatomic weight of calcium. Cystine and xanthine in the pure state give very poor shadows. The same is true of all the other common urinary salts, the urates, uric acid and triple phosphate. Of course, these constituents occur in varying proportions, and stones pervious to the roentgen rays when small may accumulate enough calcium to be recognizable before they have attained very great proportions. Perfectly transparent calculi so seldom occur that exploratory operation can hardly be justified on any such ground when the radiogram is persistently negative.

In any case of persistent pain in the abdomen which cannot be readily explained on other grounds, or of hematuria or pyuria for which there is no apparent reason, the X-ray should be brought into service in a search for possible renal calculus. Many stones are " silent," only being discovered when roentgenography is employed for some other purpose, or a subject comes to autopsy having died of some entirely unrelated disease. When they cause pain it may appear to have no connection with the renal region. At the Mayo Clinic it was noted that nearly a third of the proved calculus cases had a previous history of operation for the removal of the gall-bladder, appendix or something else, because of pain in the middle or lower anterior quadrant of the abdomen.

It is a fact that no single symptom can be postulated as absolutely typical of renal calculus. For this reason the clinical history is of comparatively little value until the bacteriologic and roentgenologic findings can be correlated with it. Eisendrath, making a clinical review of seventy-one cases of nephrolithiasis, found that while pain of a colicky or more localized character constituted a fairly large percentage of the complaints, these colics can no longer be regarded as typical of calculus disease alone. Attacks of equal severity are now known to occur in chronic nephritis, in infections of kidney or ureter, in ureteral stricture, and a number of other conditions. The same is true of the urinary findings. Any one of a half dozen lesions may put blood and pus in the urine. It is only when we can confirm these findings by some outside means of detection that they become of value as important conjunctive evidence. In a series of 184 cases of renal calculus, Young and Waters found colic occurred in 129, or 70 per cent., and hematuria in 58 per cent. Twenty-three per cent. of these patients had already passed stones when they came under examination. It is noted that the extrusion of large stones is usually preceded by an attack of colic, but that small ones may be passed with little or no pain. Yet on occasion minute fragments cause the most intense pain for many days before they are finally passed into the bladder. The history of such an occurrence is of especial importance in cases where no stones have appeared in the roentgenogram. Then the merest speck on the film is invested with importance, and it is generally wise to employ the wax-tipped catheter as an additional aid in demonstrating or ruling out calculus.

Roentgenographic diagnosis. The interpretation of the X-ray films thus becomes a matter of prime diagnostic importance. While the plain roentgenogram will often provide positive evidence, in many cases the confusion with extra-renal shadows will leave the clinician in doubt. In such a case recourse must be had to pyelography, if cystoscopic examination and the employment of the ureteral catheter have not made the situation clear.

The pyelographic data which make it possible to determine whether a doubtful shadow is within or outside the kidney are given by Braasch as (1) the distance of the shadow in question from the pelvic outline; (2) the exact relation of the shadow to the pelvic outline, and (3) the presence of pathologic changes in the pelvic outline. If the distance separating the pelvic outline from the shadow is more than 4 cm., the shadow's extra-renal indication is clear.

The routine use of pyelography is advocated by Eisendrath who claims 90 per cent. success in locating stones in the kidney through its employment. Furthermore it enables us to say with a fair degree of accuracy that a calculus lies in a given position, as at the ureteropelvic junction or in one of the calyces. When a shadow, which data previously gathered indicate to be that of a renal calculus, is included in the pyelographic outline, the diagnosis of its intrarenal nature is far more certain than when we must depend upon the findings of the opaque catheter only. Pyelography also serves to check up the renal function tests which have been previously performed, as the uretero-pyelogram of the involved side gives practically indispensable information as to (*a*) the degree of dilatation of the renal pelvis and its calyces; (*b*) the possible presence of a stricture of the ureter, and (*c*) whether the calculus formation has taken place in a horseshoe, ectopic, hypoplastic or similar form of congenitally anomalous kidney. This author also calls attention to the wisdom of considering the possibility of an associated tuberculous lesion in nephrolithiasis. He has seen two cases of this kind. In one there were multiple scattered shadows of varying density so that it was assumed before operation that stone formation had occurred secondarily in a tuberculous kidney. In the other patient the shadow was irregular but of uniform density, and the diagnosis of an associated renal tuberculosis was not made until the kidney was exposed.

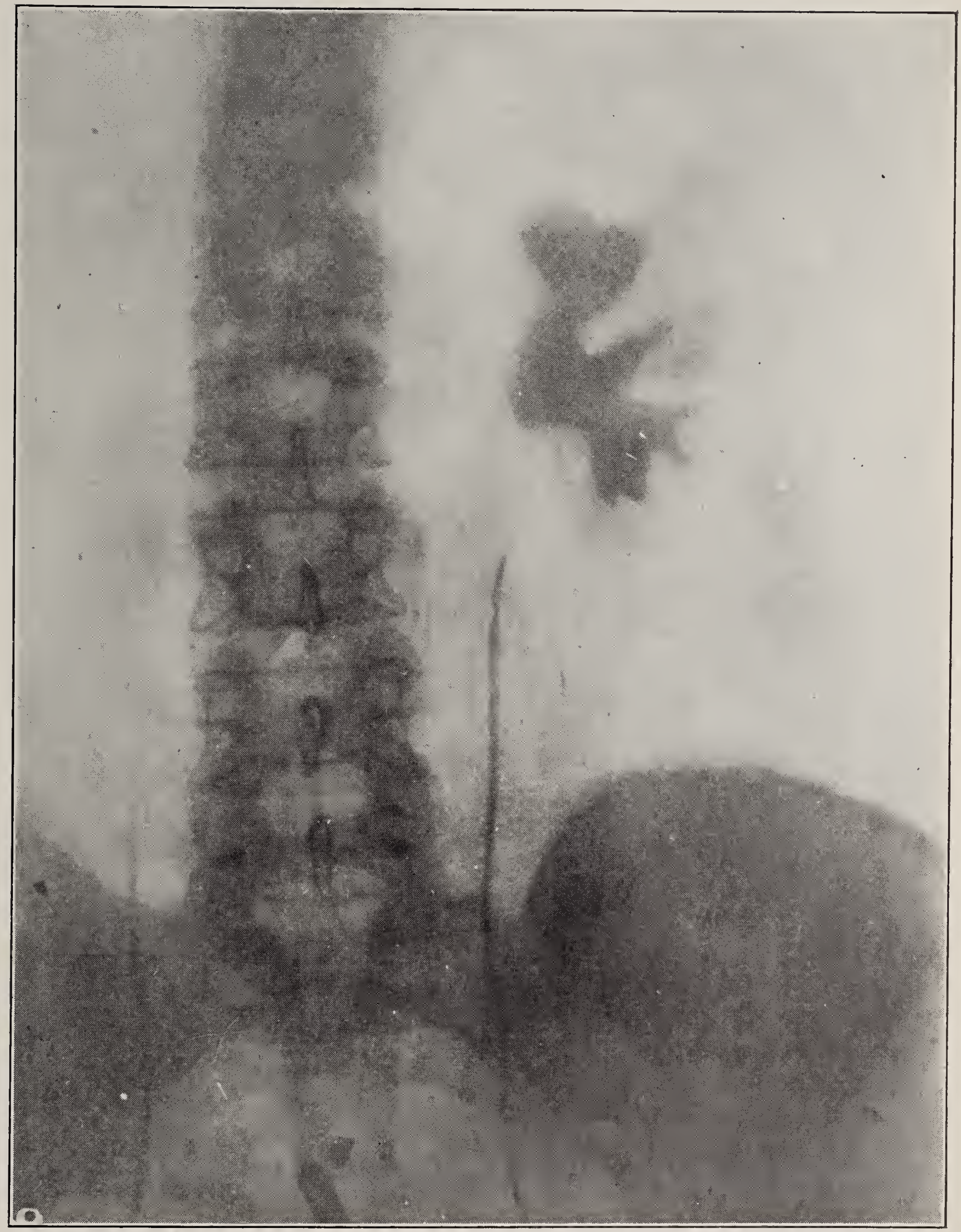

Fig. XXXIX. Renal Calculus. Entire pelvis filled with stones. Two years after operation and removal of stones the renal function is 35%, with no evidence of recurrence of stone formation. (Author's case.)

If hydronephrosis is present its existence will usually have been discovered before the examination has proceeded as far as the stage of making pyelograms. Occasionally this is not the case, and in many instances the additional corroborative evidence thus afforded will be desirable. Pelvic deformity, if present, will be shown, and permit an estimate of the extent of the damage inflicted by the stone or stones. Just what type and how extensive an operation will be needed to remove it, may usually be decided by this evidence also, as the relation of the stone to the pelvis will be revealed. Noting that a stone which casts no shadow (cystin, uric acid) may appear in the pyelogram as a clear translucent area, Waters suggests that a stone not appearing clearly in the plain roentgenogram may throw a better shadow in the second film taken after the renal pelvis is emptied, as the stone will by that time have absorbed some of the pyelographic medium. Lateral views should be made in cases of obscurity. They may be of value in determining the exact location of shadows in the kidney region and differentiating them from gall-duct shadows. Should the diagnosis still be in doubt, Kelly's wax tipped catheter should be brought into service. It has repeatedly proved its worth, though by no means invariably successful.

Diagnostic procedures used in conjunction with roentgenography. It is assumed that pyelography will not be brought into service until all other means of establishing the diagnosis have been exhausted. In any event, even when a patient presents himself with a definite history of having passed stones, a careful and complete survey of the entire genito-urinary tract should be made. Examination of the urine is a routine in every case, but at times pus and blood are only demonstrated by taking extra precautions, being present in extremely minute amount. The application of tests for renal efficiency is of the greatest moment. If operation must needs be done, it is essential to know the condition of each kidney, and it is always wise to remember that stone is likely to be a bilateral condition, even when all the symptoms are referable to one side only.

The estimation of renal function is often extremely difficult. The amount of pus found in the urine obtained by ureteral catheterization of each side separately is by no means to be absolutely relied on as an indication of the extent of the lesion in the kidney under examination. If function appears to be poor, blood chemistry frequently serves to clear up an otherwise obscure situation. Determination of the blood urea offers a good index to the patient's general condition, and may, too, give information as to the functional ability of the separate kidneys. It is important to determine these facts before the patient is subjected to the ordeal of pyelography. If operation is later decided upon, this decision can only be reached after consideration of all the facts which the functional tests and blood and urine analyses alone can furnish us.

Indications for operation. Not every renal stone should be removed by operation. The procedure is often a dangerous and traumatizing one, and delay or entire avoidance of operation is frequently desirable. It is Braasch's opinion that a stone which has been present less than six months and appears to be less than 1 cm. in diameter, which is small enough to give a good probability of its being passed spontaneously, is best left alone. In the experience of the Mayo Clinic 75 per cent. of such stones will pass spontaneously. If at the end of six months the stone has not moved and is so large that there is no longer hope of its unaided dislodgement, operation should not be further delayed.

On the other hand, if a large stone which has produced no symptoms is discovered during roentgenographic examination, the patient should be urged to permit its removal. This is because these so-called ' silent ' stones which are too large to pass spontaneously will sooner or later give most unwelcome evidence of their presence. Many such cases come under observation. No doubt some stones lie dormant in the kidney for many years, or even an entire lifetime, but such occurrences are too infrequent to warrant running the risk of a subsequent perinephritic abscess or pyonephrosis with complete destruction of the affected kidney.

At times the X-ray findings will give information of a multitude of small stones widely scattered throughout the kidney tissue, or a large branched stone may fill the pelvis and extend into the calyces. To remove these surgically without extensive damage to the kidney tissue would be impossible. So if they are not causing acute symptoms it is best to make no attempt to remove them. Nephrectomy, when the opposite kidney is competent to carry on renal function, is the only operative solution of such a problem. In old or debilitated patients where kidney function is often poor on both sides, only palliative measures are available. Livermore tells of a woman of 72 who was carried along for several years by washing out the kidney. Occasionally pus accumulated behind the stone, but a ureteral catheter could be slipped past it, and by washing out the accumulations, the difficulty could always be relieved.

Recurrent stone. No medical treatment will abolish a renal calculus already formed. We may possibly increase a patient's resistance so as to give him aid in passing it spontaneously, but even this is open to doubt. If focal infection and metabolic errors are responsible for the original formation of stones, it seems reasonable to suppose that by attention to diet and elimination of foci of infection, recurrence might be prevented. Actually it is hard to prove that such a sequence has been followed out, though cases are on record where foci of infection had been eliminated and stone formation ceased; later new foci appeared and the formation of stones again took place, to cease again when these new foci were removed.

Stones overlooked at operation. Before fluoroscopy at the operating table was possible many stones were overlooked at operation, and this doubtless still occurs with considerably greater frequency than the renal surgeon likes to contemplate. With the great improvement in preoperative localization, and the possibility of getting a roentgenographic view of all the concretions in a given kidney, our chances of removing everything were greatly enhanced, but many factors still operate to prevent complete success in every instance. What is regarded as recurrence is more often than not merely the enlargement of stones present at the original intervention but left untouched. No patient should be assured that a single operation will rid him of all chance of recurrence. But the odds are much in favor of the surgeon who uses renal fluoroscopy at the operating table, for this, or roentgenograms of the exposed kidney, are the best safeguard against overlooking calculi.

Choice of operation. When the diagnosis has once been established the renal surgeon is confronted with the problem of deciding what is the best way of handling the individual case. Operative procedure must be largely based upon the results of functional tests and the information as to number, size and location which the roentgenographical examination has furnished. While stones may form in the cortex, calyces, renal pelvis or all three places at once, those originating in the calyces or pelvis will increase in size faster than those in the cortex because substances which aid in building them up are more numerous lower down in the urinary tract.

Treatment. As a stone, if permitted to remain long enough in the kidney, will eventually cripple and destroy it, it is reasonable to undertake its removal if conditions are — or can be made — favorable. When stones are known to be present on both sides the general practice is to determine with care the functional capacity of each side, and then to remove the stones from the side which is in better condition. A few surgeons dissent from this view, and claim that it is better to attack the poorer side first, and then, when its working ability has been brought up somewhere near to normal, remove the calculi from the better side. Occasionally the patient will suffer great pain on one side and refer no symptoms to the other. It then becomes common sense to begin with the painful side, if the other kidney seems able to do the work of both while the operated one is recovering. Individual judgment will have to be invoked here as in many other cases. The most powerful factors in the final determination ought to be the position of the stone or stones and the degree of obstruction which is existent. For example, when a stone is free in the pelvis on one side, so as to produce intermittent blocking, or is impacted at the uretero-pelvic junction so that function is much impaired; while on the other side a stone is so placed in the renal tissue that it is not interfering with the outflow of urine, or doing any permanent damage to the kidney; it is evident that the stone causing rapid destruction should be the first to receive attention.

In all cases the surgeon must consider whether it will harm the kidney more to leave the stones in it, or to submit the organ to the trauma necessary to remove them. It is also essential that when operation has been undertaken and the kidney has been opened, that all the stones present should be removed. Fluoroscopy at the operating table is a great help in accomplishing this last desideratum, and should be at hand whenever possible. If the kidney is known to be infected, as is often the case, the wisdom of extensive exploration must always be questionable, for the trauma thus inflicted will do more permanent injury than leaving the stones in the renal tissue.

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VI

SOLID TUMORS OF THE KIDNEY

The classification of renal tumors is a subject upon which much ink has been spilt. Even today the leading pathologists do not agree upon their nature and nomenclature, and to the average physician, to say nothing of the layman, the entire subject is still much befogged. In the *Atlas of Pathologic Anatomy*, which appeared serially in connection with the *British Journal of Surgery*, a brief and clear epitome of the vexed subject is given, which may be transcribed as follows: There are three groups of tumors of the kidney which are naturally easily separable one from another. (1) Growths arising from the renal epithelium, which are by far the most numerous; (2) Tumors of connective-tissue origin, i. e., sarcomata; and (3) Hypernephroma, the origin of which we generally follow Grawitz in assigning to adrenal 'rests' persisting in the kidney from the stage of fetal development. This is the commonly mentioned 'mixed tumor,' composed of embryonic tissue and seen most often — though by no means exclusively — early in life.

We are in the habit of regarding all kidney tumors as malignant. It is true that benign renal neoplasms are rare, but as a matter of fact all new growths of the kidney are relatively uncommon, forming no more than 2 per cent. of all neoplasms observed. It is probable that many benign growths in the kidney do not produce symptoms, so that their presence is never discovered. Occasionally they are observed at autopsy upon subjects dying of wholly unrelated diseases, which would seem to lend importance to such a theory.

Benign renal growths. Though clinically benign many of the nonmalignant tumors of the kidney have a rapidly fatal effect because of the pressure which they exert upon structures the integrity of which is essential to life. Prompt removal may mitigate these effects but the growths frequently recur. A discussion of such neoplasms was recently published by Watson of Toronto, who reported two cases, the second being an autopsy specimen obtained from a male of 62 years who died from peritonitis, with no history of a kidney complication.

Reviewing the literature Watson distinguished four general types of benign renal neoplasms: The true hypernephroma; the true lipoma;

a combination of lipoma and hydronephroma; and the mixed fibrolipomyomata, with or without tendency to sarcomatous characteristics. Ewing has reported small multiple lipomata found beneath the renal capsule or occupying the position of certain portions of the cortex, frequently extending into the medulla. From Borst and Selter we have descriptions of lipomata of regular dimensions, which are located chiefly in the upper pole of the kidney. True lipomata are rather generally conceded to attain no greater size than one centimeter in diameter, and it was Selter's belief that what appeared to be larger ones are in reality replacement lipomatosis which takes its origin from the pelvic fat. That these growths proliferate through fatty infiltration of the connective tissue of the kidney, while at the same time there takes place parenchymal and glomerular necrosis, was the contention of Beneke. Very large growths have nevertheless been reported, that of Alsberg being of particular interest in that it resembled Watson's clinical case in many particulars. It was as large as a good-sized grapefruit, containing numerous aggregations of fibroblasts when microscopically examined, so that its structure suggested that of a spindle-cell sarcoma. There were likewise numerous sharply defined yellow nodules scattered throughout the substance of the kidney. One of Watson's tumors was so large as to greatly interfere with the function of the kidney to which it was related; the other had never caused any clinical symptoms so far as could be determined. In the clinical case there was a second, unrelated tumor entirely outside the renal area proper, with no connection between the two growths.

Among a reported series of mixed kidney tumors Hasner describes one "considerably larger than a man's head" which involved all the neighboring viscera to such an extent that surgical removal was out of the question. Extensive metastasis to the diaphragm attested the malignant character of this growth, but death was not due to that, but to the pressure atrophy in the adjacent viscera.

Adenoma. In the cortex of sclerotic kidneys small multiple adenoma are a relatively common observation. A kidney which appears to be clinically quite normal may yet harbor a small adenoma, that in the course of time may grow to considerable dimensions and produce well defined clinical symptoms. The structure of all such tumors is very similar, consisting of a papillary process presenting a central core of fibrous tissue surrounded by cubical or columnar epithelium arranged in layers. Though classed as a benign growth any adenoma of the kidney may become malignant, and should always be regarded with suspicion.

In general, it may be stated that though benign renal tumors occasionally come to operation, their occurrence in clinical practice is de-

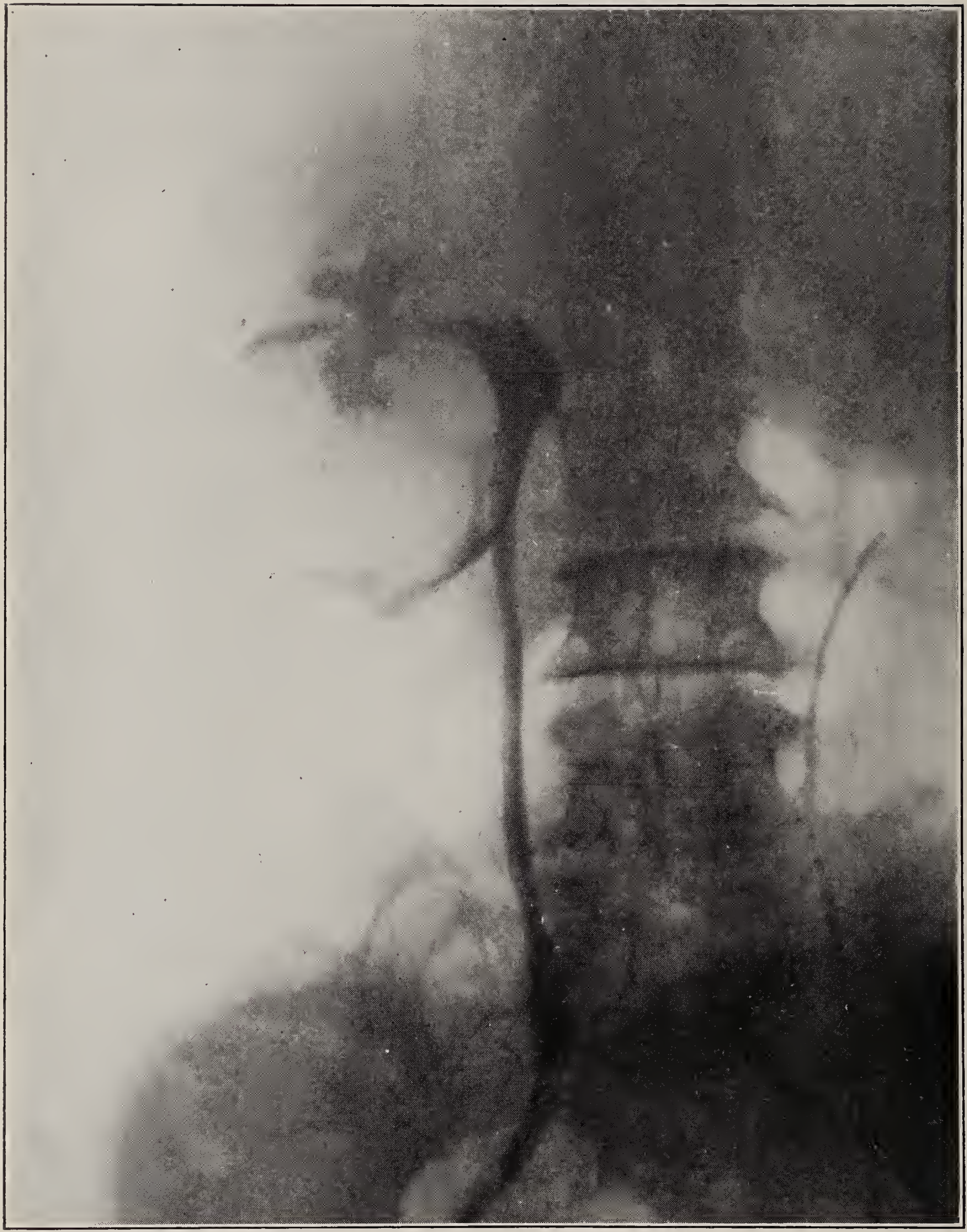

Fig. XL. Hypernephroma. Note the characteristic deformity of the renal pelvis. The tumor has encroached upon the cavity of the pelvis until nothing more than a thin cuplike shell surrounds it.

cidedly uncommon. Arkin has recently stated that the fact that benign hypernephromata are frequently found at autopsy would argue that these tumors are actually much more prevalent than we suppose, because they seldom become malignant or produce symptoms of any kind. Transition to malignancy appears to take place through some influence of which we at present have no conception, and this influence rarely operates before the subject has passed his fortieth birthday. Benign growths are seldom found in children or young adults. Though the papillary adenomatous growth usually designated *hypernephroma* may exist for many years and remain wholly benign, it is nevertheless potentially malignant, which is evidenced by its well known tendency to invade the renal veins. Eventual metastasis is the rule, secondary deposits being found in far-distant portions of the body, especially in the osseous structures. A bone lesion or a tumor mass in an anatomical part far removed from the kidney will often be the first sign of a neoplastic growth in the kidney.

Malignant renal neoplasms. It is customary to discuss tumors of the kidney proper and of the renal pelvis as separate entities. This is because pelvic growths in general partake of the nature of bladder neoplasms rather than resemble those found in the renal cortex. In the pelvis papillary growths are the rule; in the kidney itself the so-called hypernephroma greatly predominates. As has already been intimated, so much confusion exists regarding the origin and pathology of these tumors that any just estimation of them is extremely difficult. Still, as one has very wisely said, for clinical purposes, the origin of the tumor is relatively unimportant. On detailed examination with the microscope, though many different types of cell and of cell structure will be seen, there will also be one common feature. This is a high lipin content. Under the ordinary methods of staining the cells will be finely vacuolated, or clear and pale. Columnar, tubular, alveolar or papillary arrangement are very likely to be present simultaneously, observable during examination of a single specimen. But in the entire group of tumors there seems to be always one type of cell evidently of renal, or possibly adrenal, origin. It was noted that loss of definite cell arrangement in the entire extent of the tumor, or even in relatively small parts of it, as well as the observation of polymorphous and spindle-shaped cells which take staining very solidly, always indicated a growth which was highly malignant in type.

Hypernephroma. The ‘ Grawitz tumor ’ which is a somewhat more exact designation than hypernephroma, because this name has been so loosely applied to all types of kidney tumor, benign and malignant, is the most prevalent form of malignant renal growth. It is generally lobulated and encapsulated, though often broken up by areas of necrosis, and its uniformly orange or canary-yellow color — found in the most remote metastasis — may be varied by hemorrhagic spots, or the variations in shade produced by the presence of fibrous connecting bands which unite the component lobules. This yellow color is due to the fat content of the protoplasm with which the large columnar polyhedral cells are filled. A delicate connective tissue, pierced here and there by numerous fine blood-vessels, forms a basis for this cell-structure.

'Mixed tumors' of fetal origin. Birch-Hirschfeld (1894) is generally recognized as the first to call attention to the characteristics which differentiate this type of renal tumor from the more frequently observed neoplasms. He asserted that they arose from remnants of the Wolffian body. Wilms, five years later, denied the possibility of such an origin, because striated muscle fibers, a common component of these growths, are never found in the Wolffian body. He believed that it was from the undifferentiated mesodermal tissue that later gives origin to not only the Wolffian body, but the pronephros and myotomes as well, that these tumors arise. When this undifferentiated tissue proliferates, tubules may be produced which closely resemble those in the Wolffian body. There may also be included such embryonal muscle cells as are often seen in these growths, and even cartilage may be present if some of the sclerotome chanced also to be included in the 'rest.' With such a mixture of tissues, any one may predominate. Though these tumors always develop inside the kidney, it is not at the expense of the renal tissue. The organ only suffers from pressure, and eventually from the atrophy thereby induced. The cell-structure often suggests sarcoma. Indeed, the sarcomatous nature of these growths is still held strongly by skilled pathologists. The line of demarcation can certainly not be drawn very sharply. The most strongly marked characteristics are: Appearance early in life — usually before the second year; Encapsulation, and the production of relatively few metastatic growths, except when the primary tumor is unusually large; Complete inclusion of the primary growth within the kidney, but without inclusion of any actual kidney substance in the structure of the tumor.

Carcinoma. In contradistinction to hypernephroma, carcinoma grows at the expense of the kidney, quickly destroying and replacing it entirely. It does not usually appear until the 'cancer age' is reached, and seems to afflict men much more frequently than women. When surgically exposed, such a growth will appear to the unaided eye as a solid infiltrating tumor of whitish aspect which has not appreciably altered the size or shape of the organ whose place it has usurped. Often the calyces and renal pelvis will not be invaded in any way, but so great will be the compression exercised upon them, that function is entirely inhibited, and in consequence no hematuria will give evidence of the conditions existing. Microscopically many of these carcinomata are papillary in structure, with large-sized epithelial cells, columnar in shape and filled with clear protoplasm. Often the form will be that of tubular adenocarcinoma closely simulating the appearance of normal renal tubules. Its most common manifestation however, is as a nodular circumscribed tumor, which is clearly defined from the surrounding renal tissue. It may attain a large size before producing symptoms urgent enough to send the patient in search of medical advice. When exposed it is always easily differentiated from sarcoma, which is rare in the adult kidney, and will always show the recognizable features characteristic of this particular type of growth when seen in other parts of the body.

Tumors of the renal pelvis. As has already been stated, the papillary type of tumor is that most often found in the renal pelvis. They occur at the ‘ cancer age ’ and though their etiology, like that of other cancerous growths, is still unknown, the evidence that trauma may be closely related to their appearance, is quite conclusive. Nearly always some infection of the kidney is, or has been, present, and stones are frequently found in conjunction with it. Papilloma are probably always benign at the outset, but tend rapidly to become malignant. It is an open question as to whether they originate in the renal pelvis and extend to the bladder, or whether they begin in the bladder and are conveyed through the ureter upward to the pelvis. In either event it would seem likely that the ureter would suffer from an extension of the process, but actually this seldom occurs, as neoplastic growths of any sort in the ureter are far more unusual than in either bladder or kidneys.

The structure of these growths is similar to papilloma in other locations, a feathery, ramifying process springing directly from the mucosal epithelium. Hematuria is an early symptom of the majority of these growths because they are always highly vascular, consisting almost wholly of thin-walled blood-vessels held together by transitional epithelium. At times a firm solid growth will develop beneath this feathery exterior, and this may grow backward, infiltrating the kidney proper. Secondary growths smaller in size are not uncommon near the site of the primary tumor.

Diagnosis. Hematuria is practically the only indication of the existence of a neoplasm in the kidney until such time as the growth has attained sufficient size to produce palpable or visible tumor. If the bleeding be very abundant clots may form, the passage of which will produce a sharp colic similar to that caused by the movements of calculi. If the

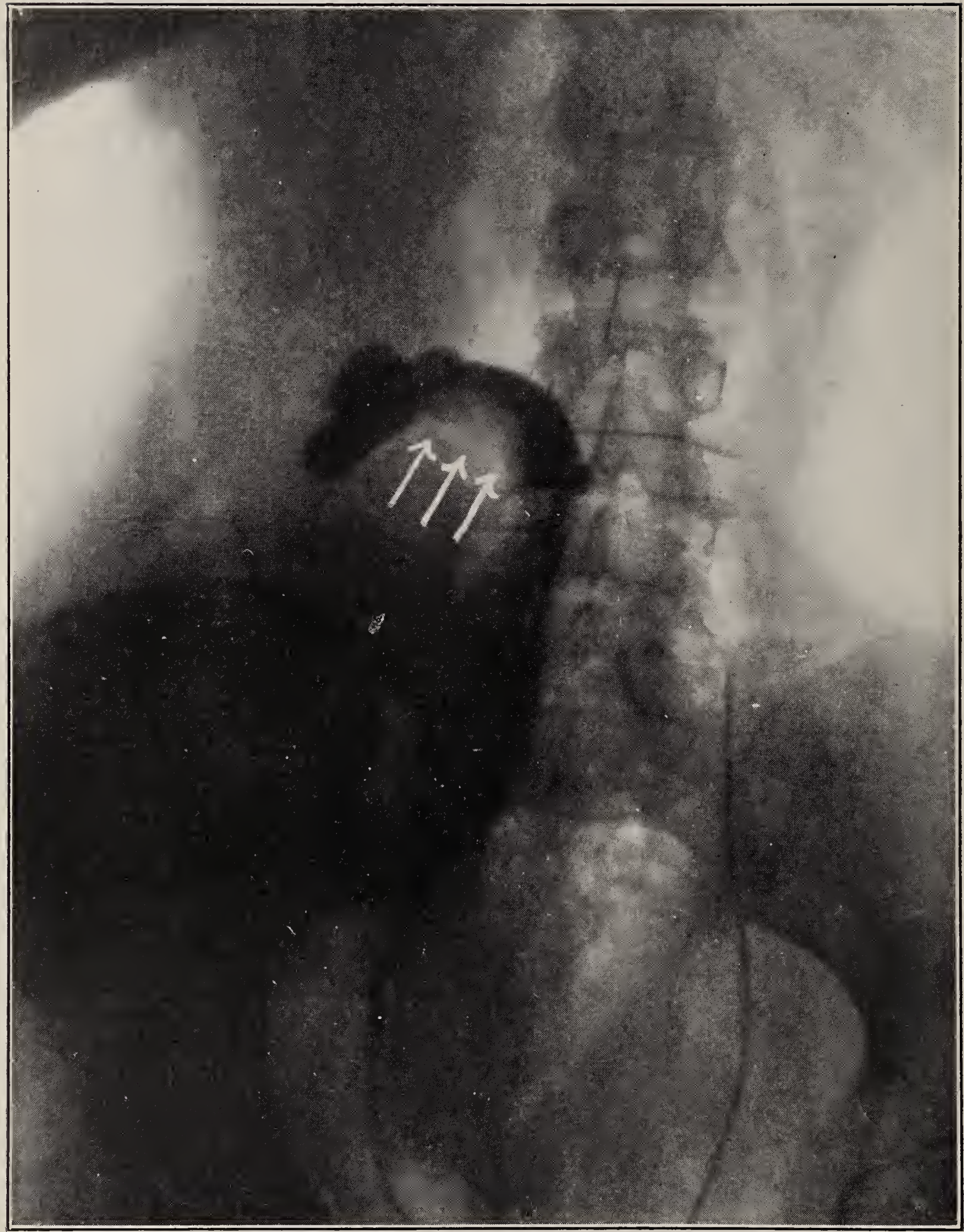

FIG. XLI. Hypernephroma. Calyces are obliterated and pelvis greatly misshapen.

outflow of urine is impeded by these clots, hydrenophrosis will be induced and its characteristic symptoms put in evidence. Most of the growths occurring in the renal pelvis are papillary in character and as these are always highly vascular — as has already been pointed out — blood is likely to appear in the urine quite early in their evolution. Extension to the bladder by way of the ureter is also likely with this type of neoplasm, and when cystoscopy reveals papillomata in the bladder and catheterization shows unilateral bleeding, it is highly probable that we have to deal with a papillomatous growth in the renal pelvis on that side. When the growth has attained considerable size there will be pressure symptoms manifested in various ways, though at present, diagnosis can usually be established before it is sufficiently advanced to produce these symptoms to any marked degree.

Roentgenographic appearance. When tumor is present in the kidney, no matter what its origin or nature, the fact will be indicated in the roentgenogram by enlargement and abnormality in the outline of the kidney shadow. Nichols, a roentgenologist with much experience in urologic work, states that these alterations are visible in the roentgenogram before any mass can possibly be palpated. A pyelogram at this stage may show flattening of the calyces by suppression, or the calyces may have wholly disappeared, while the pelvis will be elongated and misshapen. When this appearance is observed and enlargement of the kidney proper likewise appears, the diagnosis of renal tumor is well assured. If the growth is a cyst instead of a solid tumor it may cause distortion of the pelvis and calyces indicative of compression, but the kidney shadow outline will be smooth and definite, indicating that the cortex is distended. As cysts do not often cause such clinical symptoms as hematuria and pain at the time when they give such a roentgenographic appearance, this may serve as an aid in differential diagnosis between cysts and solid tumors. If malignant tumor is suspected, a careful X-ray examination of the entire skeleton may reveal metastasis, even when the renal growth has not as yet produced noteworthy symptoms.

Elongation of the calyces is, according to Braasch, the most characteristic finding in roentgenography in cases of hypernephroma and adenocarcinoma. The major calyces may be constricted and flattened throughout, while the minor calyces may be tapering, often with a hooklike termination. Usually but one or two of the major calyces will be involved. When alveolar carcinoma is present the growth will involve a greater extent of the wall of the pelvis, and it is probable that instead of elongation and narrowing of the calyces, we will see them shortened and irregularly dilated. At times the growth into the lumen of the pelvis will be so extensive as to dilate or even partly obliterate it. A firm irregular tumor which has grown rapidly and has a distinctly irregular outline of pelvic lumen, with abbreviation and necrosis of the calyces, rather than elongation, would strongly suggest alveolar carcinoma. Add to this a long history of renal lithiasis, and a present rapid loss of weight, and the suggestion may well become a certainty.

Value of pyelography. The importance of pyelography in the diagnosis of renal tumors is not as yet fully recognized, but such diagnosis will become more general as the skill of radiographers devoting their attention to this particular application of X-ray work increases. A well marked filling defect is very reliable evidence of pressure upon the pelvis or its calyces, or of its actual invasion by a renal growth. When the compression is brought to bear in such a way that the outflow of urine is obstructed, the results of pyelography may be the presentation of a picture of hydronephrosis from an entirely different cause, which will, of course, cause much confusion. Braasch says that the differential diagnosis between renal neoplasm and the ordinary type of hydronephrosis can usually be made by the characteristic outline of the pelvis occurring with pyelectasis. Difficulties in differentiation may arise when there is a degree of obstruction of the uteropelvic junction sufficient to prevent enough opaque medium from entering to outline it properly. Also when the pyelectasis occurs secondarily to tumor of the pelvis. Under these circumstances enough medium will usually enter to show an outline, but there will be only streaks or crevices to represent the pelvis, and there may be irregularity in the outline of the uteropelvic junction. In cases of simple hydronephrosis in which partial occlusion exists, little or no opaque medium may enter the pelvis, and the small amount that does find entrance will be so diluted by the retained fluid that the shadow will be dim and diffuse. As renal aplasia and tuberculosis give similar outlines due to occlusion, the interpretation of plates showing such deformities may be extremely difficult.

Perirenal growths. Certain changes in the pyelographic outline due to perirenal conditions, worthy of special attention, were recently noted by Eisendrath and Koll. If the perirenal compression is in intimate relation to the parenchyma, the chief effect will be distortion of the pelvis and calyces. But if the cause of compression is further removed, the displacement is more likely to be outward or inward toward the ureter, and associated in some degree with renal torsion. Atrophic pyelonephritis may have a similar distorting effect upon the calyces.

In general, a fairly good-sized renal tumor will give an irregular shadow, more or less nodular in character, which is either continuous with the renal shadow normally visible, or appears to have usurped its place entirely. The tumor shadow is of greater density than that cast by the normal kidney tissue.

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NEUROLOGICAL PHASES OF UROLOGY

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THE BLADDER

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THE BLADDER

BLADDER FUNCTION

Capacity. The urinary bladder is a receptacle the capacity of which varies with associated sensations, with alteration in its shape and size from childhood to male or female adulthood, with the degree of muscle power brought about by increase or lack of resistance in its outlet, and the degree of lymphatic or hematogenous bacterial absorbability associated with inflammatory changes, manipulation, or self-trauma of forceful contraction. It influences the upper urinary tract through alterations due to age, sex, anomalies, and altered muscle or nerve factors. All these are of clinical importance and can be appreciated by an interpretation of symptoms and an analysis of the history and clinical findings.

The amount of urine which normally calls for an emptying response can be considered as the *voiding capacity.* It varies at birth from twenty-five to fifty cubic centimeters. At that time the bladder is pear-shaped, the stem upward, and sloping toward the umbilicus, with the urethra above and posterior to the symphysis. In the next four years of life the bladder descends rapidly[17], the urethra moving downward and forward, until, when empty, it is a " Y " in shape. Descent then continues slowly until the twentieth year, at which time the urethra is two centimeters above the lower border of the symphysis, the trigone remaining fixed as the bladder distends upward and laterally. In distention, the greatest diameter in the male is vertical and in the female transverse, due to variations in the bony pelvis. The capacities associated with these changes cannot be specified but in the normal individual they vary with the weight or specific gravity of urine and the chemical irritation associated with its concentration.

The female bladder has a capacity of 75 to 100 cc. more than the male after the sensation of " fulness " has been reached; that is, it is more distensible than the male, although it responds similarly to the early sensation of filling.

Bladder-wall musculature. The mobility of the adult organ, from the fixed urethra and trigone, is made possible by three layers of interlacing muscle bundles. The bundles of the inner and outer longitudinally placed layers are heavier nearer their points of fixation. Here they are fewer in number and more widely spaced than over the lateral walls and dome, where they are fine and closely woven. Consequently, when muscle hyperplasia occurs in obstructed bladders the inner (longitudinal) muscle layer shows, cystoscopically, as coarse trabeculæ over the floor and at the points of trigonal attachment. In certain slowly progressing obstructions the muscle bundles of the dome may even show as fine bands, taut partitions, or small areas of weaker wall, convexed by the increasing intracystic pressure of filling. The circular middle muscle layer contributes to the formation of the internal sphincter and shapes the bladder, its contraction pulling in the lateral walls and opening the internal sphincter; while the inner and outer longitudinal layers *add* powerful antero-posterior compression. The lateral walls being less compressed, we have, in consequence, the " Y " shape of the empty bladder.

As the bladder empties, this musculature becomes more powerful with contraction; hence the slowness of the start of the stream in an overdistended bladder and the quickness of its start in an unobstructed bladder with a pathological small capacity.

The internal sphincter. The internal sphincter muscle undergoes compensatory and decompensatory changes associated with the bladder wall — changes caused by obstruction. Its action is involuntarily associated with the bladder wall, being passively closed with a passive wall and actively open with an actively contracted bladder wall.

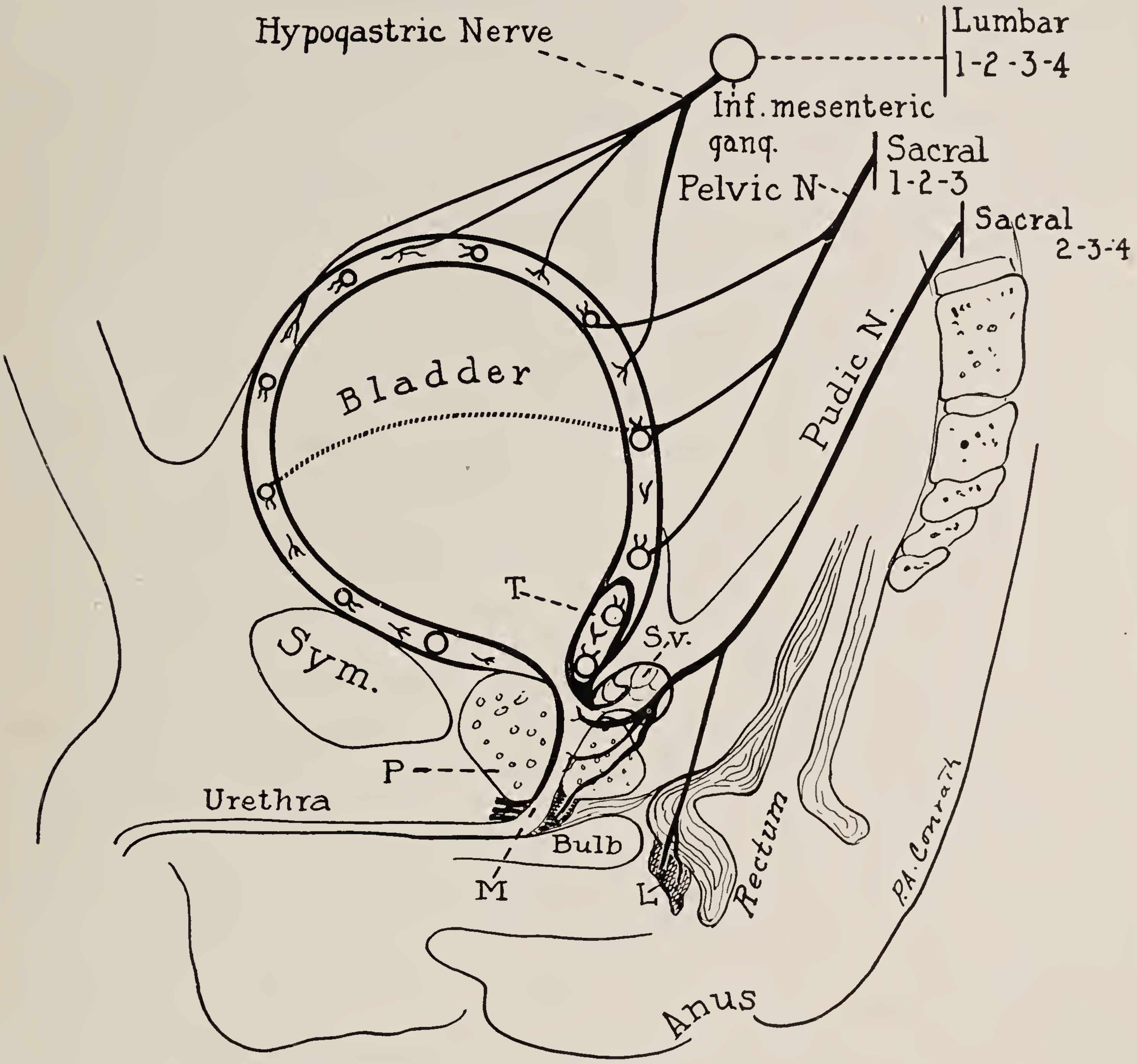
The trigonal muscle[65,68], named for the trigone of Lieutaud, could be called the trigger muscle in that its contraction initiates the flow of urine from the bladder by guttering the floor of the internal sphincter, thus allowing a few drops of urine to stimulate the posterior urethra.

The external sphincter. The external sphincter consists, functionally, of the mechanism between the internal orifice and the opening of the fixed membranous urethra. Its action is two-fold: compression and disalignment of these openings. The compression occurs at the internal sphincter, the prostatic urethra in males, and within the membranous urethra. Part of this compression is direct, or by opposite wall contact, and part by alteration in the plane of the urethra. To retain urine one pulls up on the perineum and, if further resistance is necessary, the action of the adductor group of muscles is added. To initiate voiding the openings are aligned by depressing the perineum. This action of a pump-handle-like type has its fulcrum at the internal sphincter, with the handle throughout the proximal mobile urethra. It is done by the levator ani muscle chiefly, with the accessory action of other perineal skeletal muscles, the perineii, ischiocavernosus, and bulbocavernosus in particular. They therefore contribute to urethral-wall compression, as well as being all-important in the disalignment of the openings mentioned. By this action less direct compression is necessary at the internal sphincter and within the membranous urethra to resist a high or, particularly, a suddenly increased intracystic pressure[52].

Intracystic pressure. In instances of extremely poor bladder-wall tone in neurogenic cases, the question arises as to whether smooth muscle has inherent contractility. Physiologists differ on this point. Clinically it is unimportant, as it is insufficient, if present, to raise the intracystic pressure to a marked degree.

Intracystic pressure, as judged by working with the cystometer[44] developed in the Department of Surgery, Washington University Medical

School in 1926, is raised by abdominal wall squeeze between the fixed perineum, diaphragm, and abdominal wall muscles. How much of this raised intra-abdominal pressure is actually transmitted to the bladder contents and how much of this same pressure initiates further involuntary bladder-wall pressure is variable. Measurements vary from two to possibly one hundred millimeters of mercury at most while descent of the diaphragm with deep inspiration, if fairly rapid and with the abdominal wall partly fixed, causes a rise of two to five millimeters of mercury. The



M = Membranous urethra
T = Trigonal muscle
P = Prostate
Sv = Seminal vesicle L = Levator ani muscle
♀ = Pelvic nerve terminals (craniosacral)
⅄ = Hypogastric nerve terminals (thoracolumbar)

rise in intracystic pressure upon coughing, talking, sneezing, crying, laughing, et cetera, varies with the degree of muscular contraction involved. This is obvious and has no clinical significance excepting that, if the bladder is partially filled and is further contracted by outside muscle force, this increased tone, in a bladder with normal innervation remains, reduces slowly, or incites further involuntary bladder-wall contraction.

Nerve supply. The bladder wall and internal sphincter are in control of the autonomics and react as gracefully, immediately, and constantly to the weight and concentration of urine as does the pupil of the eye to the intensity of light. In the eye, atropin, by paralyzing the parasympathetic terminals, leaves the dilator nerves in control, which merely means an increase in the diameter of the pupil. In the bladder, the action of the same drug simply means dilatation which, however, expresses itself in a larger capacity, slower contractility, and lowered intracystic pressure.

All physiologic bladder phenomena have to do with muscular or myogenic factors and the nerve control. It is not known whether the stimulus necessary to contraction is initiated by the nerve terminals within the mucous membrane or the muscular wall of the bladder or in the urethra, nor do we know the importance of cord and brain centers. The manner of the innervation of the bladder wall must take definite form in our minds. In spite of the mass of conflicting experimental evidence, Elliott[19] finds that the vesical innervation varies in different animals. Epinephrin[52] stimulates both motor and inhibitor sympathetics (cervicothoracicolumbar); the motor effect can be cut out by ergotamine, leaving the inhibitors intact. By this means, inhibitor fibers to the bladder wall are shown, their influence constantly shaping the cystometric curve. The parasympathetics (cranio-sacrals) to the internal sphincter (trigonal area) figure largely in the incontinence of urgency.

Clinical observations and symptoms are definitely changed from those expected experimentally, often by the fact that the nerve lesions are diffuse, the stronger influences overbalancing the weaker though moderated by the latter as well as by the condition of the bladder wall — whether it is elastic, fibrous, atonic, or hypertrophic, and by its state of irritability. Psychic influences are easily interpreted as variations from the normal pathological innervation curves.

The cystoscopic diagnosis of neurogenic bladder is now based on finding diminished urethral sensation and tone; that is, visualizing the posterior urethra and internal sphincter, possibly a raised trigone, and interpretation of the type of trabeculation, together with general observations. Such data are incomplete and often subject to error. With the bladder wall as an index, however, all factors based on its innervation can be considered in a more accurate manner, together with the recognition of the internal and external sphincter and bladder-wall changes.

The preponderance of evidence is in favor of the belief that both motor and sensory fibers travel in the same nerves, as brought out by Langley and Anderson[31], and that the autonomic innervation is crossed. The behavior of the urinary bladder is a counterbalance between the action of the sympathetics (vesicothoracicolumbar pathway) (Ranson[41]), through the inferior mesenteric ganglion — with outflow from between the second dorsal and the third lumbar anterior roots, stimulation of which " excites contraction of the internal sphincter (trigonal area) of the vesical musculature, causing retention of urine —" and the parasympathetics (vesicocraniosacral pathway [pelvic nerve]) with outflow from the first to the third anterior sacral roots, stimulation of which " excites contraction of the vesical musculature exclusive of the internal sphincter (trigonal area), the contraction of which it inhibits and thus produces urination." With these conclusions Barrington[3] agrees. Thus, as Jackson[29] observes, the sympathetics " control the mechanism of vesical filling and the sacral supply directs the mechanism of emptying the bladder." Further, Barrington[3, 4] shows that the pudic nerve partially controls sensation of the posterior urethra and also supplies its tone and that incontinence occurs when the pudics are cut but to a less degree than when both the pudics and pelvics are cut. He feels that the pelvics carry the sensation of pain.

Moore[38] shows that the bladder mucosa has sensibility to temperature and localized physical stimulation. Our cystometric conclusions are that the pain of overdistension is via the hypogastrics, surrounding nerves, viscera, and peritoneum; bladder-wall tone is via the pelvic nerve; and desire to void pelvic partially but *pudic nerve chiefly.*

Barrington[3], working with cats, found that removal of the inferior mesenteric ganglion increases frequency by removing inhibition and that the frequency does not attain its maximum at once but continues to increase for some weeks. This constitutes a parasympathetic overbalance, not as definitely found clinically so far; but the " frequency . . . increases for some weeks " is a good example of the myogenic factor coming in secondary to the nerve change, the myogenic factor simply being that frequency means small capacity, contracted wall, higher intracystic pressure — all increasing as frequency increases, a vicious circle.

Head[25] states that lesions of the mucous membrane of the bladder affect the cutaneous area of the lower sacrals (third and fourth) while the pain of ineffectual contraction is diffused over the eleventh and twelfth dorsal and first lumbar areas. He further finds that with irritation of the parasympathetics the " bed would be always wet," that is, incontinence of small amounts, frequently associated with desire; whereas, with stimulation of the sympathetics, a paradoxical incontinence of large residual urine with overflow would result. He states that if this type were catheterized two or three times a day the " bed would never be wet." For a third lesion above the ninth thoracic from fifteen to twenty ounces (450 to 600 cc.) of urine would pass without the patient's knowledge, this being a complete, normal, but automatic act.

The voluntary rectal sphincter, in its intimate association with the levator ani (N. pudic) and its internal sphincter innervated from the first to the fifth sacral segments, is obviously affected in very nearly the same manner under similar conditions, normal or abnormal, as are the bladder sphincters. When one set (bladder sphincters) is hyper- or hypo-irritable or atonic, the function of the other (rectal sphincter) is often altered in the same manner; although, with a discreet lumbosacral or sacral cord lesion, the bladder sphincter may be diametrically opposite in reaction to the rectal sphincter. This can be caused by the cord lesion more recently involving (irritating) fibers to the spastic sphincter while the fibers to the atonic sphincter have suffered greater destruction. A hyper-irritable rectal sphincter may simulate an atonic one in that, with the stimulation of the first touch by the examining finger, it actively opens and remains so.

Barrington[5] believes that the urethra relaxes (afferent and efferent via the pudic nerve). Also, that bladder contraction, by somatic nerve reflex, occurs, as seen in some automatic bladders, upon simply stroking the skin of the abdomen or thigh.

In the three pairs of nerves concerned, Dennig[16] shows that the function of a cut nerve will be assumed by others.

Cerebral control. In general, the literature agrees that the cerebrum exerts a constant though variable degree of inhibition.

Schwarz[57] feels that micturition is not subject to direct exercise of the will but that, by the psyche, inhibition of reflex mechanisms can be removed.

Beattie[6] believes that the nerve control is exercised mainly through the pelvic and pudic nerves; that the sensory nerve supply of the bladder is carried by all three sets of nerves, of which the pelvic carries the greatest number of sensory fibers. He further believes that in addition to cortical control there exists a hypothalmic control which alters the tone of smooth muscles, a bulbar center essential for reflex micturition, a sacral center which permits of spontaneous micturition, and a lumbar center whose integrity is necessary in reflex micturition. He believes these centers are definitely interdependent.

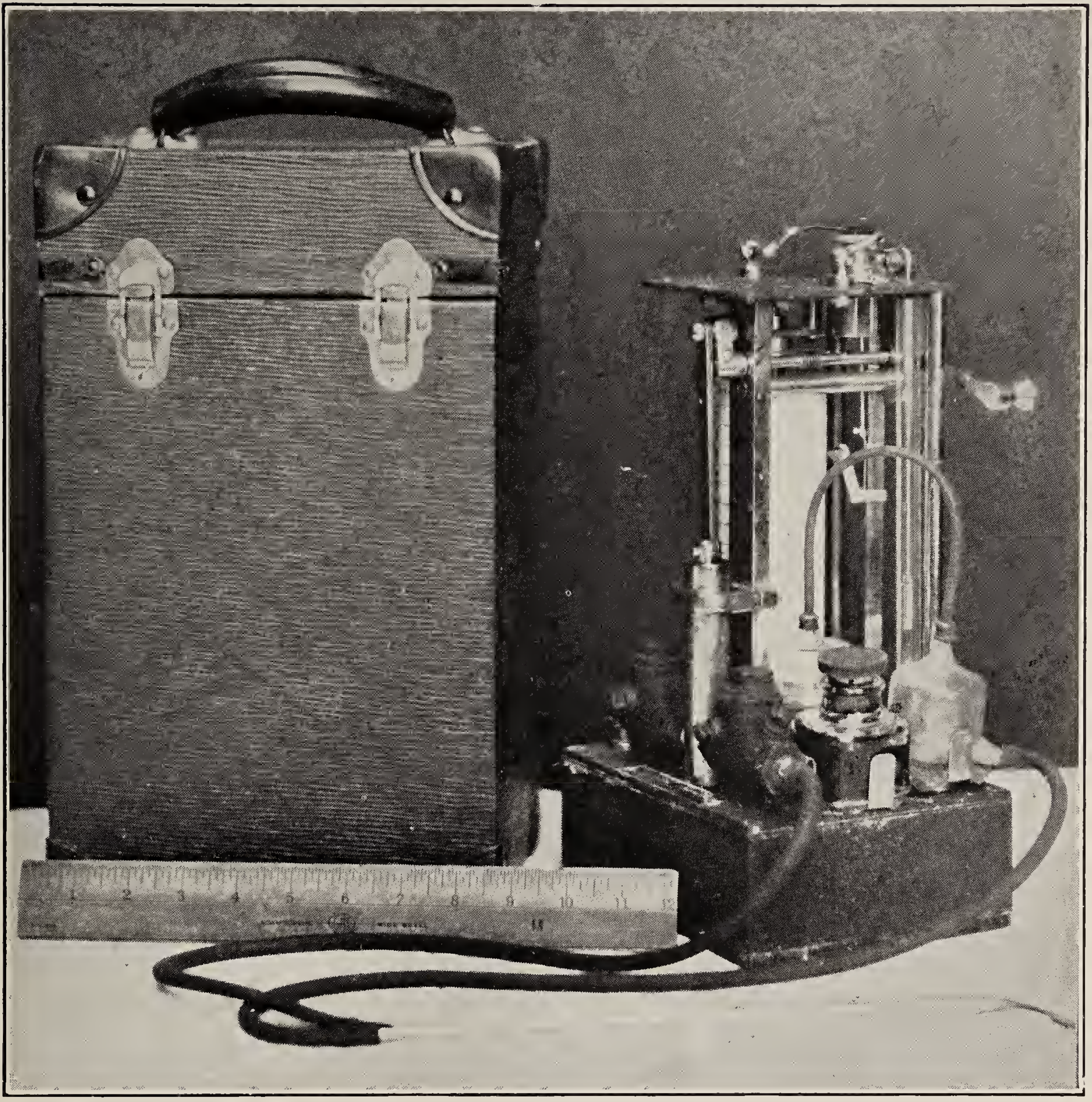


FIG. 2. CYSTOMETER. The one-foot ruler rests against the water container, above which the pump is shown. By turning the handle, eighteen revolutions per minute, 270 cc. of cool water flow into the bladder through a two-way catheter (No. 18 French). Pressure leads out through the two-way catheter to a mercury manometer. The test is made under constant conditions as to time of bladder filling, size of catheter used, temperature of water (cool), position of the patient, and the cystometrogram taken on a graphic cylinder showing the simultaneous reaction of the bladder wall as to its strength (which is divisible into myogenic and motor nerve factors) and sensory responses. Two curves, one following the other almost immediately, are always taken.

Barrington[3, 4, 5] determined a micturition reflex in the hind brain of the cat, using the stereotaxic instrument of Clark[12]. He concludes: " Bilateral lesions at the anterior end of the hind brain just ventral to the internal edges of the superior cerebellar peduncles resulted in a large volume of residual urine, whereas similar lesions near but not exactly in this position did not affect micturition. This is not a part of the brain where chronic disease is frequent in man; retention of urine, however, does occur in pontine gliomas."

Cystometric measurements. Rose[44, 45, 46, 47, 48, 49, 50, 51, 52, 53], Muschat[39], McKinley[35], Redewill[42]. To make a cystometrogram the patient lies flat, relaxed, a two-way metal catheter in the urethra. After a lapse of one to two minutes any muscular contraction resulting from catheterization relaxes. Water of a temperature within five or six degrees of normal body temperature is pumped in at a constant rate and the cystometer simultaneously records pressure and quantity of fluid within the bladder. On this line between two ordinates (1) quantity of fluid and (2) intracystic pressure, the following sensations are recorded: (1) slight pressure, normally about 100 cc.; (2) (*) first desire to void, about 150 cc.; (3) fulness, from 250 to 350 cc.; (4) pain, moderate 400 to 500 cc.; and severe pain, 500 to 650 cc.

In disease of the nervous system, with large residual urine, over-filling is unwise as it may break down the remaining bladder-wall elasticity. In infected bladders of increased muscle resistance it may exacerbate or generalize the infection to the extent that a plain cystoscopy may.

Two curves are *always* taken, the second following the first by two to three minutes, for the reason that stretching normal, smooth muscles with quick release acts as a marked stimulus. If the second curve shows an abnormal increase or decrease in strength, with a corresponding alteration in capacity and placement of sensations, it will give diagnostic evidence of muscle or nerve change in instances in which a single curve is without definite diagnostic value.

In our experience it has been found necessary to have the intracystic pressure line continuous rather than to take a reading after putting a given amount of fluid into the bladder and then recording the pressure-capacity line in steps.

Cystometric conclusions. The act of micturition is determined by a balance between bladder-wall expulsive force and combined sphincter resistance.

Response of "desire to void" is due to weight of fluid in the bladder and, possibly, to certain chemical concentration.

The act of micturition is under the control of the will.

So-called "psyche inhibition" is due to skeletal muscle tonus, notably the levator ani, which maintains the posterior urethra tilted upward so that the normal tone of the internal sphincter need not be great to keep urine from the posterior urethra.

An absence of micturition centers in the cord.

Bladder wall and internal sphincters store or release fluid through the action of the autonomics and pudic nerve as outlined.

The external voluntary sphincter, when acutely pulled up, can stop the act of urination midway and initiate it anew at will. To stop the stream the perineum is pulled upward; to initiate it the perineum is depressed.

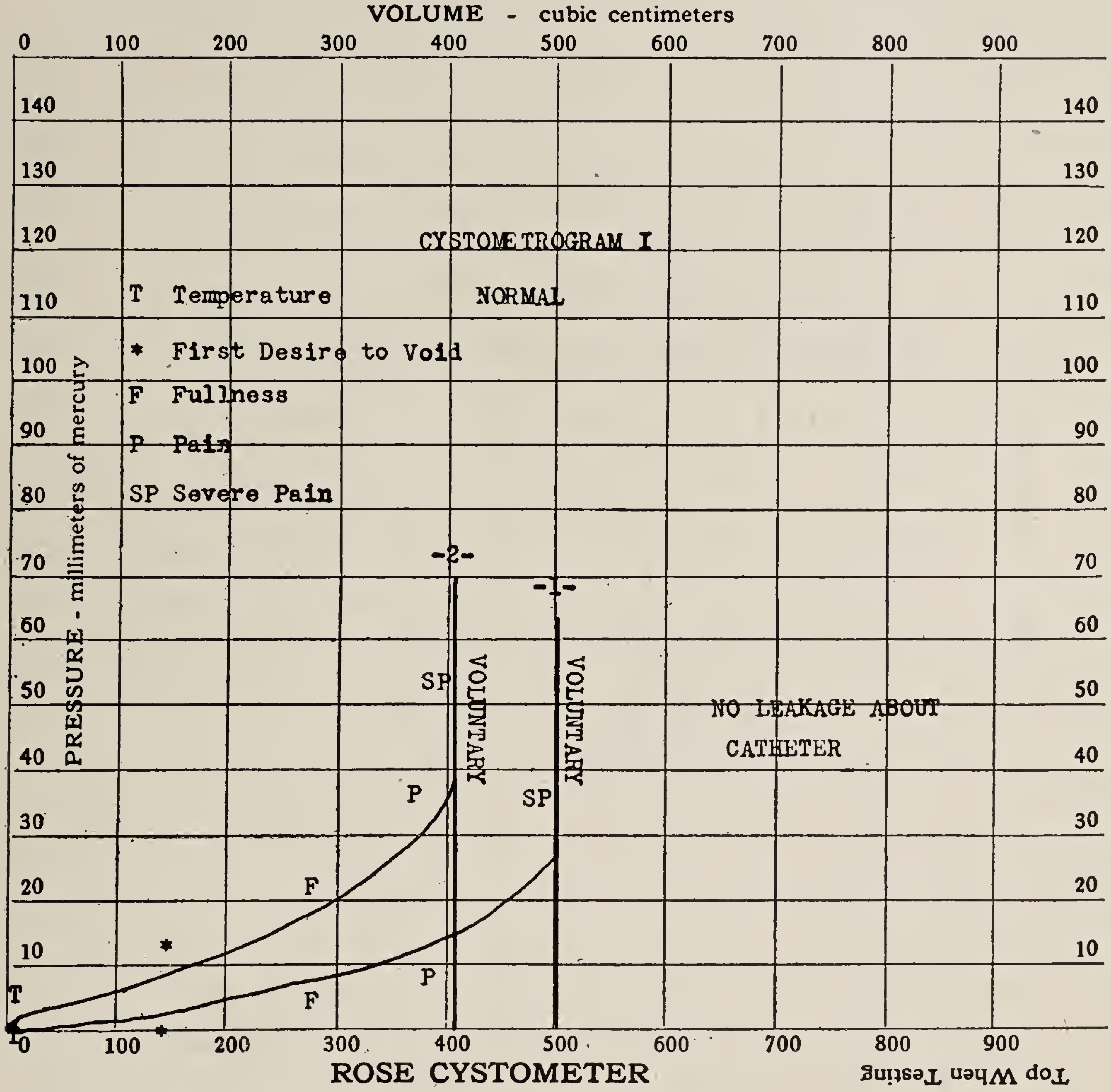


FIG. 3. (CYSTOMETROGRAM I) NORMAL. Represents a type of normal, fair capacity, gradual increase in pressure with the various sensations properly placed. (See key on Cystometrogram I for explanation of sensation points as marked on the curves.) The second curve shows a slightly increased pressure and diminished capacity.

The following seven cystometrograms (figures 3 to 9) are shown as types of tracings obtained in a normal bladder and in a few pathological conditions. These are presented simply to explain the method and not to define a type associated with any one condition as all are individual.

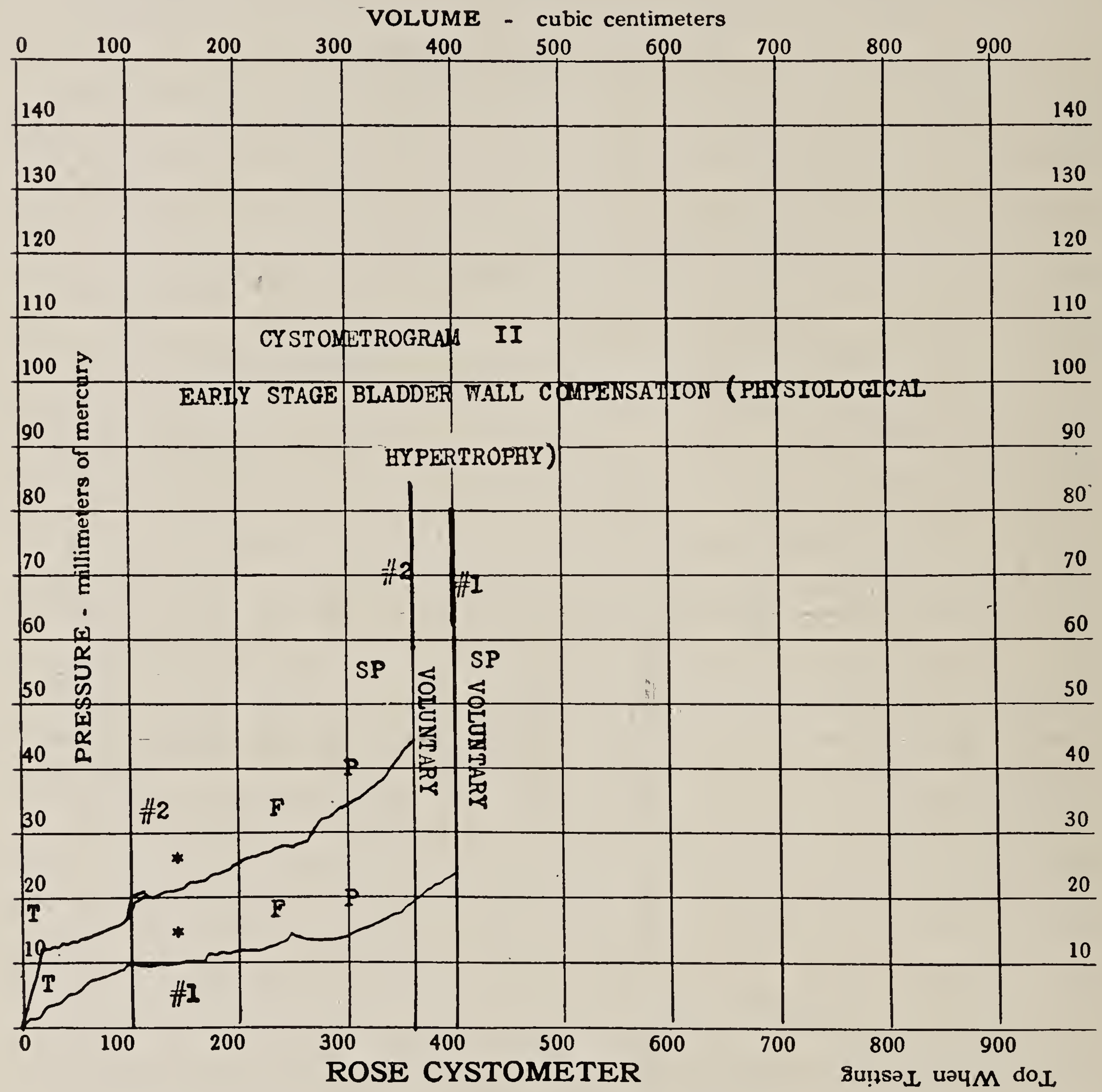


FIG. 4. (CYSTOMETROGRAM II). In comparison with Cystometrogram I, pressure is slightly increased, capacity smaller and sensations normally placed. The bladder wall is beginning to thicken.

Micturition. The sequence of the various steps in the act of micturition are, in my opinion, as follows:

(1) Accumulation of the proper quantity, specific gravity, and chemical concentration of fluid to notify of its presence. This notification is brought about by a slight increase in the tone of the bladder wall and resistance of the internal and external sphincters (afferent and efferent

both pelvic and pudic nerves, but chiefly pudic nerve). The primary increase in bladder-wall tone, an involuntary reflex initiated by the weight of urine, may be influenced by extraneous forces altering intra-abdominal pressure. Among such forces we consider upright position, exercise, intra-abdominal pathology or skin reflex, abdominal or perineal muscle contractions, psyche, and rectal pressure or irritation.

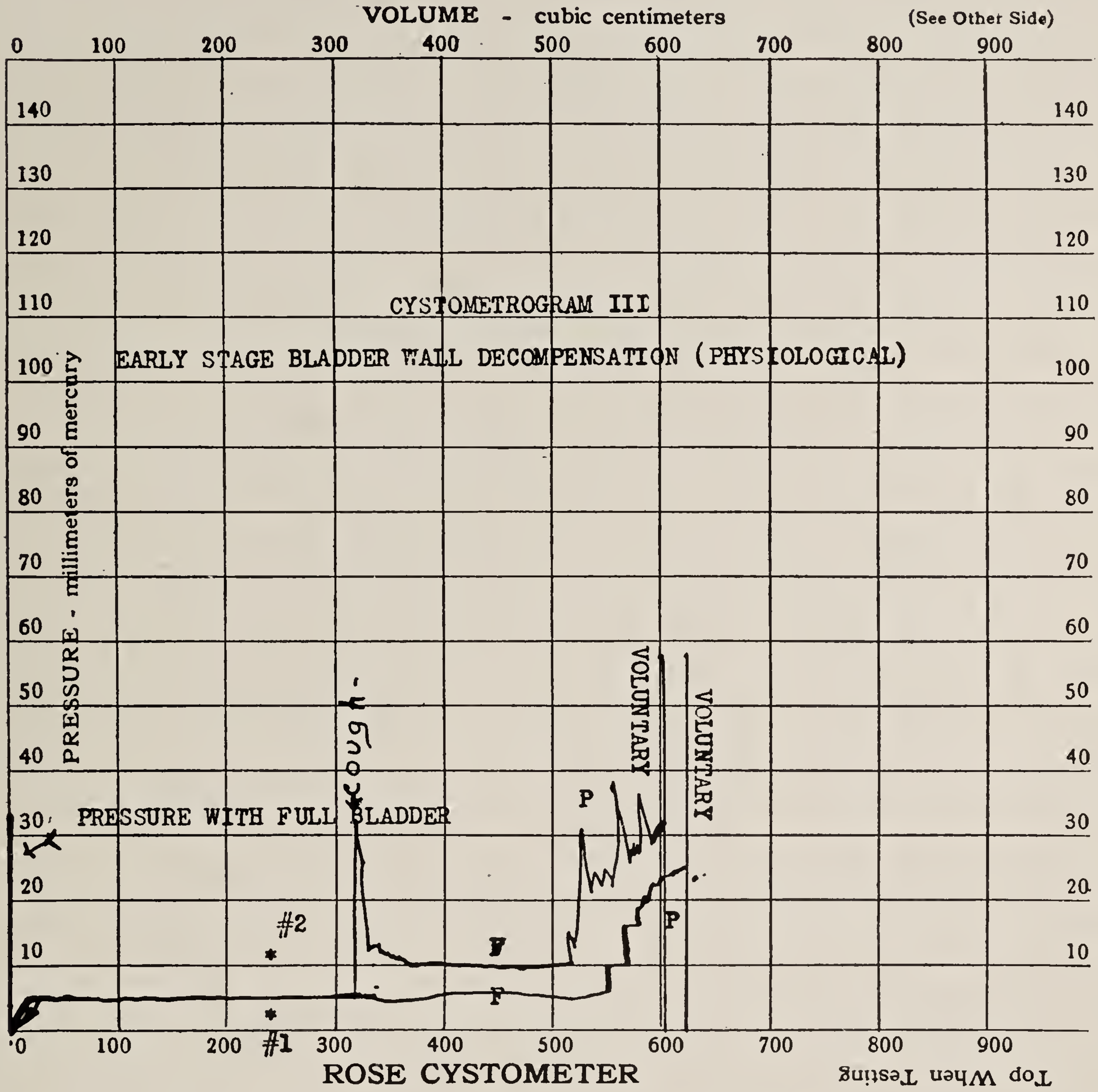


Fig. 5. (Cystometrogram III). Illustrates bladder-wall decompensation in its early stages. Sensation, "first desire to void" is delayed to 250 cc., capacity is increased and pressure lowered.

(2) To obey the notification of a "desire to void," the mobile portion of the posterior urethra is first depressed, lessening angulations and con-

sequent resistance of the sphincters. This is a voluntary action brought about chiefly by the anterior portion of the levator ani muscle, innervation, pudic nerve.

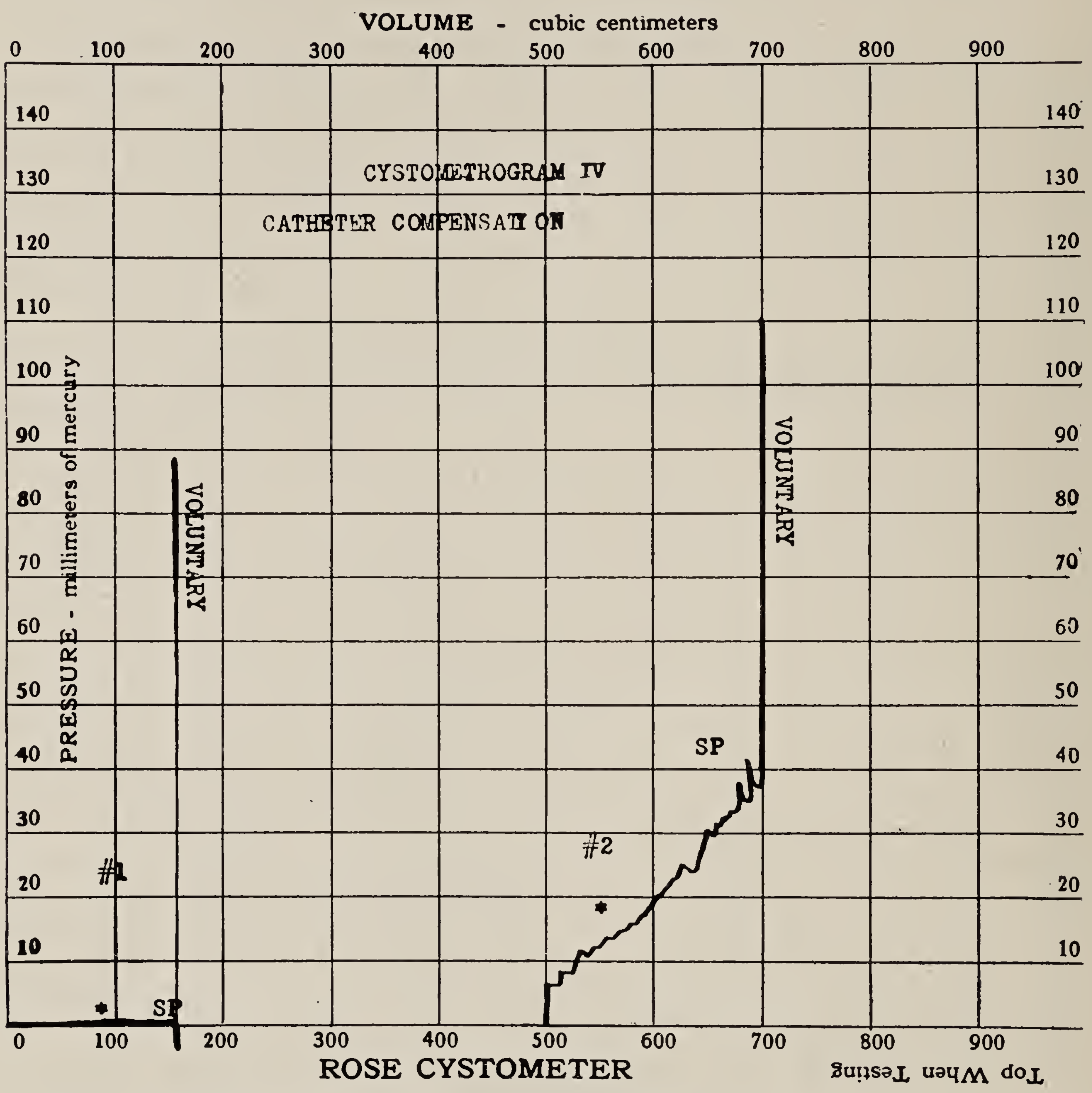


FIG. 6. (CYSTOMETROGRAM IV). Shows the catheter compensation after a retention catheter has been left in. We have pressure raised, capacity lowered, and sensations heightened. Before using the catheter a cystometrogram showing low pressure, large capacity, and somewhat delayed sensation was obtained.

(3) Contraction of the trigonal muscle, guttering the internal sphincter, and allowing urine to escape into the posterior urethra (pelvic nerve).

(4) Stimulation by the fluid in the urethra initiating the contraction of the wall of the bladder and dilatation of its internal sphincter, afferent pelvic and pudic nerves.

(5) Flow of urine through the urethra stimulating the pudic, afferent and pelvic, efferent.

(6) Stopping the act at any time by voluntarily elevating the mobile urethra, levator ani muscle chiefly, though as in starting the bulbocavernosum plays a minor part, (N. pudic in terminal emptying of the bulbous urethra).

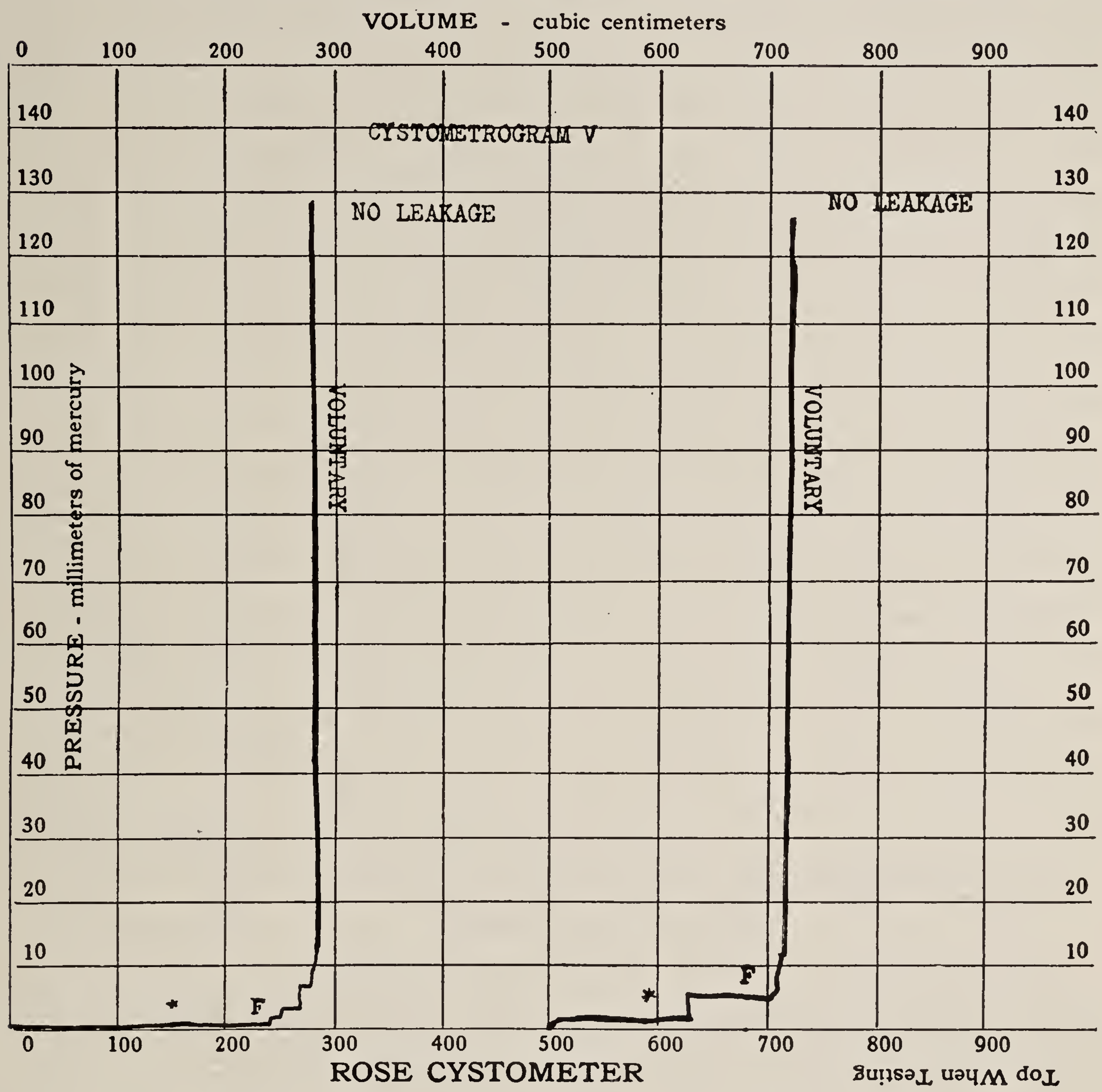


Fig. 7. (Cystometrogram V). Demonstrates what happens to a bladder following ineffectual transurethral surgery. Shows tremendously high pressure caused by the bladder maintaining its compensation long after operation, showing that obstruction is still present and, in this instance, there remained a small residual urine. Capacity small, pressure high, sensations normal.

(7) The act terminates as the dilatation of the urethra by flowing

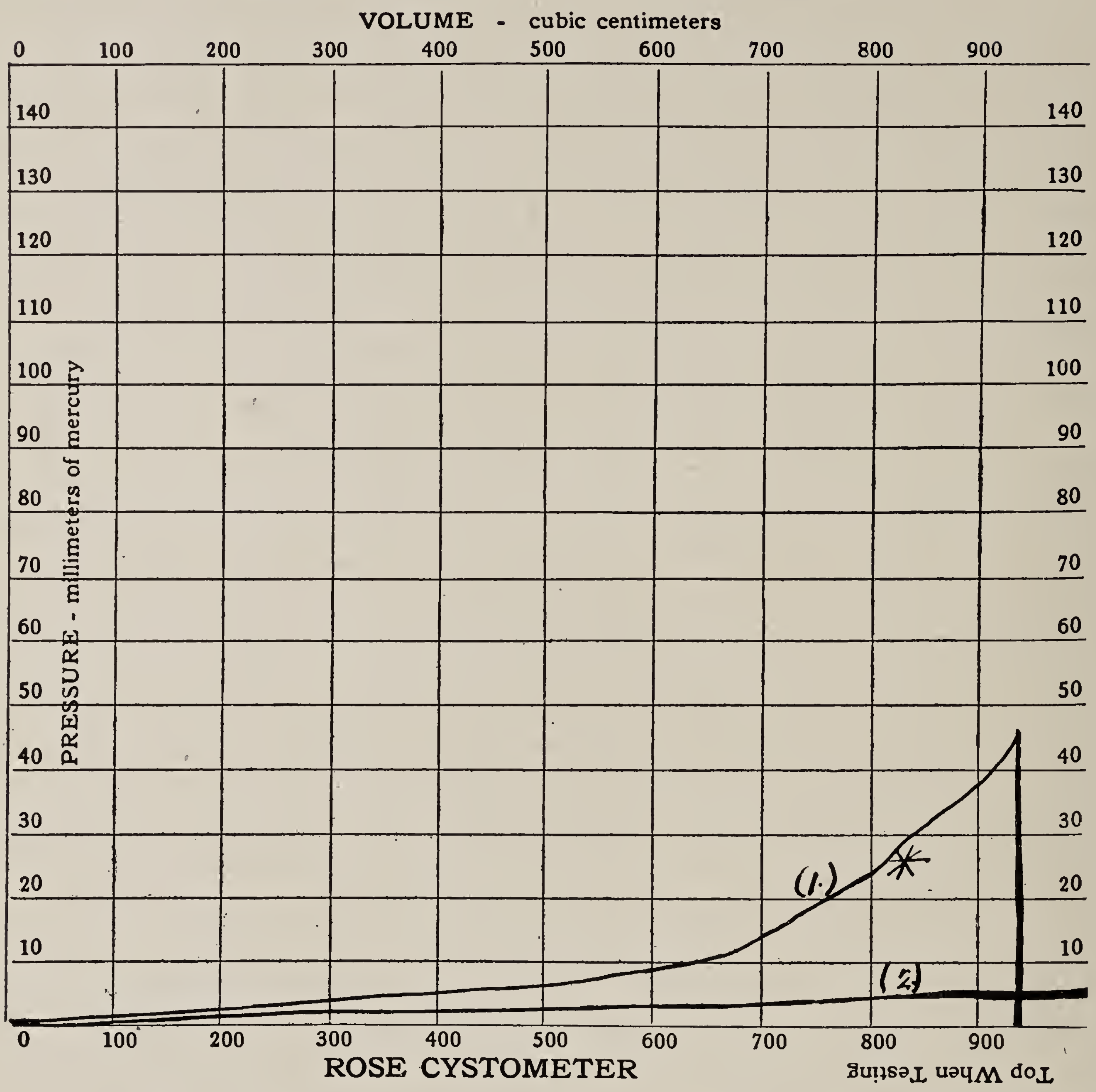


Fig. 8. (Cystometrogram VI). An atonic type of neurogenic bladder, spinal fluid Wassermann positive, large residual urine (350 cc.). The point to note especially is that in the first curve the desire to void was delayed to 850 cc. and even then was rather indefinite. However, there is greater bladder-wall resistance in the first curve than in the second, due to the over-distention of the first curve. This only occurs in the presence of faulty innervation. In the second curve there was no desire to void noted by the patient although the bladder was filled to 900 cc. This curve shows the inadvisability of over-distending a neurogenic bladder. This type of neurogenic bladder also compensates very slowly to either intermittent or continuous catheter drainage.

urine diminishes, as the volume of the urine within the bladder diminishes, and as the rapidity of bladder-wall contraction lessens. These factors lessen afferent stimulation and allow the influence of the sympathetics to come in and reëstablish the normally passive bladder.

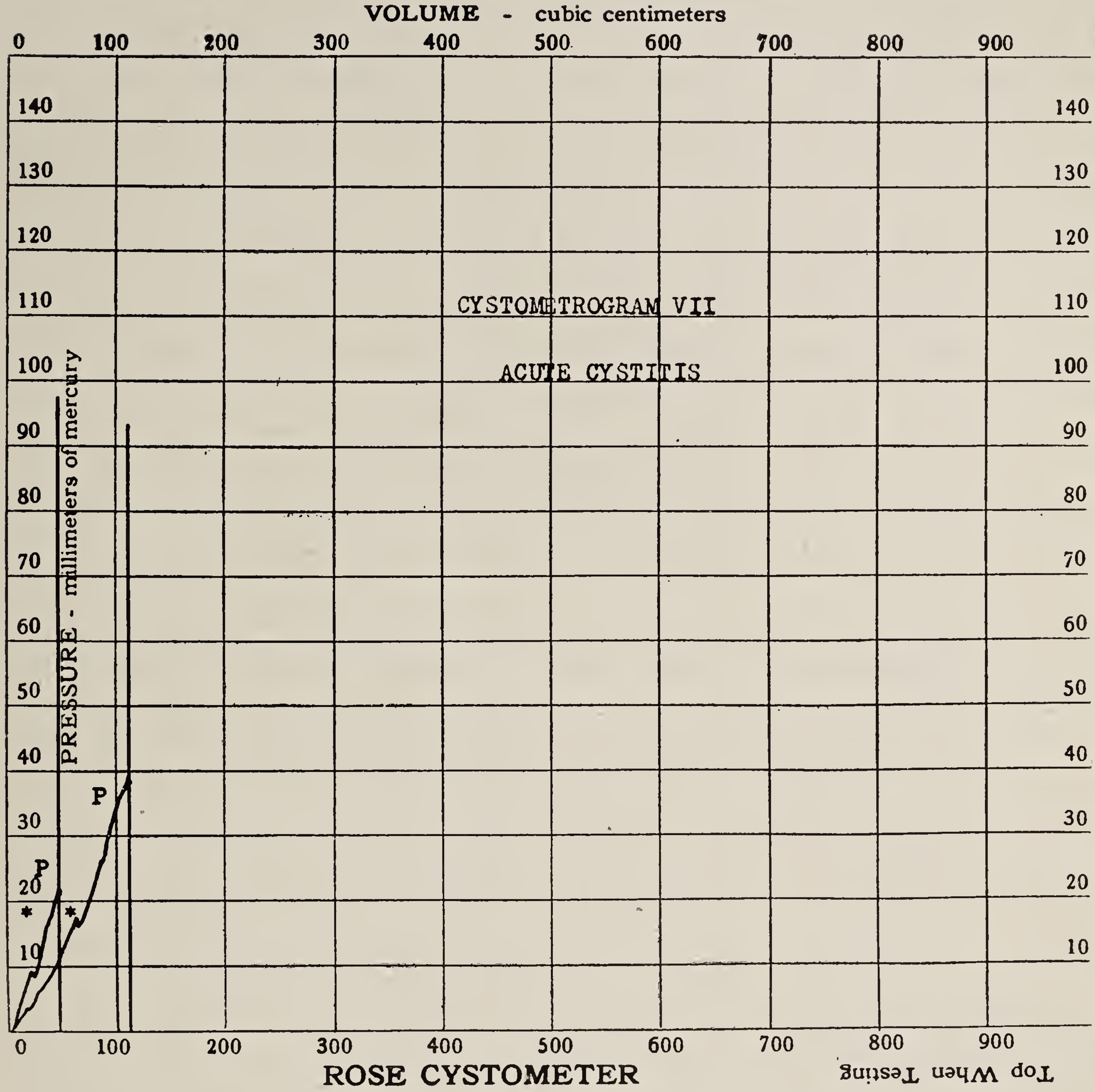


Fig. 9. (Cystometrogram VII). Illustrates an acute cystitis, very small capacity, and sudden high pressure with pain. A similar curve is obtained with meningeal irritation.

INTERPRETATION OF SYMPTOMS

On the basis of the foregoing, with but few additions we may analyze important symptoms such as: (1) frequency of urination, (*a*) day, (*b*) night; (2) urgency of urination; (3) painful urination, (*a*) initial, or when the stream starts, (*b*) continuous, (*c*) terminal pain, with or without tenesmus; (4) incontinence, with or without the subject's knowledge and with or without pain; and (5) stream, its start, flow, and stop.

Frequency. The frequent passage of small amounts of urine is due either to a bladder of small voiding capacity or to the overflow of an overdistended bladder. In either case it is an *insufficient* muscular elasticity. A small voiding capacity may be due to:

(1) *Urethritis.* Irritability of the posterior urethra, increasing the pudic nerve reflex, maintains a small capacity and causes an initial high rise of intracystic pressure which, in part, is due to the contracted, thickened and strong bladder-wall muscle.

(2) *Cystitis.* Irritability of the bladder mucous membrane desiring to release itself from the weight of fluid. The urethra of an infected bladder may or may not be hyper-irritable.

(3) *Foreign body.* Constant state of contracted bladder-wall musculature in an effort to expel a pathological mass of tissue or a foreign body. A diverticulum, yet not to be emptied through its small neck, acts in the same manner upon the bladder wall and may be classified as a foreign body.

(4) *Intramural cystitis.* By its lack of elasticity causing a " pinch " bladder-wall reflex contraction before a normal distension of the bladder wall is reached.

(5) *Pericystitis.* Altering frequency in type and degree by its intensity and location. It acts as does intramural cystitis in keeping the bladder wall in a state of contraction, low capacity, and high pressure.

(6) *Meningeal irritability.* Slight pressure, infection, neuritis, maintain a low threshold of reflex stimulation. If the irritation is pudic nerve alone, we have an increased sphincter resistance with gradual loss of frequency as the bladder wall decompensates back of this resistance.

Urgency of urination. This is a voluntary act and implies normal innervation with abnormal peripheral stimulation or central nervous system hyper-irritability. It is voluntary in that the subject hastens to void the bladder before the involuntary rapidly increasing intracystic pressure exceeds all possible sphincter power of resistance. In such extremes there are: (*a*) Fixation of the diaphragm in semi-inspiration and distention and fixation of the abdominal wall. That is, the intra-abdominal pressure is decreased and the hypogastrics apparently stimulated to *active* bladder-wall distention. Cystometrically[47], I have seen a 10 mm. of mercury *negative* pressure created by these reflexes with probably an added psyche-sympathetic reflex. (*b*) Contraction of the perineal muscles and the urethral sphincter muscle in the urogenital trigone, and contraction of the adductors muscles to further compress and elevate the mobile portion of the posterior urethra.

In differentiating a markedly decompensated bladder wall back of a mechanical obstruction from a tabetic bladder, if there is a long previous but definite history of urgency, it points to the former. Urgency of urination is seen in meningo-vascular or irritative types of cord syphilis and, rarely, in well-established tabes dorsalis. In the latter case it is apparently due to a late and beginning involvement (irritation) of portions of the sacral cord (pudic and pelvic nerves).

Painful urination. When occurring at the start of the urinary stream it is an exaggeration of the " desire to void " (pudic nerve) plus the pain of distending inflamed urethral walls. The pain just before the stream starts is due to increased tone of the sphincters. This increase in tone is in response to a too rapidly rising bladder pressure (pelvic and pudic nerves).

Continuous pain denotes an acute urethritis.

Terminal pain is caused by self-trauma of opposite walls of the bladder and urethra at the termination of a too rapid and too forceful contraction.

Tenesmus. This is an exaggeration and continuation of this terminal self-trauma, each terminal forceful contraction stimulating a repetition of the contraction until physiologic fatigue occurs. Of course, such a bladder has a small " voiding capacity " and consequently the tenesmus is soon repeated.

Incontinence. As a symptom of imperfect bladder function, incontinence has, from the neurological standpoint, two principal divisions: (1) incontinence occurring *with* the patient's knowledge, and (2) incontinence occurring *without* the patient's knowledge.

Involuntary incontinence is: (1) The " spill-over " of a distended bladder with a normal central nervous system. The dilated bladder with a weakened, thinned wall, under its " pressure anesthesia " (caused by pressure on the intracystic nerve terminals by the weight of a large, constant residual urine), abruptly transmits altered intra-abdominal pressure upon stooping, suddenly arising, coughing, et cetera, and causes the loss of small amounts. It is also caused by weak, unrecognized contractions stimulated by the large content. In the early stage of this type, knowledge (urgency) is associated, but in the extreme cases the response of the nerves under long-weight pressure of urine becomes dulled. However, the pudic nerve will register the passage of urine through the urethra. The external sphincter becomes the chief guarding muscle and its reflex is slowed.

(2) Loss of small amounts in females with cystocele varies with the type of cystocele as brought out by the important work of Van Duzen[62, 63]. Loss on coughing, sudden exercise, et cetera, is due to a weakened

sphincter function with normal innervation. In cystocele, in which the trigonal muscle is detached at the internal sphincter, ineffectual yet forceful sphincter muscles may cause a hyperplastic urethritis with consequent pudic nerve hyper-irritability, resulting at times in an uncontrollable urethral-bladder reflex. Infection soon occurs in a residual urine and heightens all the reflexes.

(3) Incontinence, day and night, in psychopaths is often not associated with cord bladder changes. It is a disinterested voiding at the wrong time and place. The bladder is usually emptied completely.

(4) In central nervous system syphilis, with nocturnal incontinence, the incontinence is most frequently due to a loss of sensation, permitting the bladder to remain distended, or partially so, over long periods and thus cause secondary myogenic decompensation and intracystic nerve terminal pressure anesthesia even greater than that which would occur with a similar residual urine in a bladder of normal innervation. The tone of the voluntary sphincter, if reduced, is compensated for during the day by maintaining accessory voluntary control muscles in contraction when necessary. At night this guard is relaxed and urine leaks out into the urethra, starting the reflexes of urination. Loss may occur down to the standard residual, or only a small amount may be voided, according to the nerve damage and the bladder-wall status.

(5) Enuresis nocturia in children is occasionally (Campbell)[11] (Bleyer)[7] seen in children in whom all findings are negative excepting a hyper-irritability of the parasympathetica (vagotonia). In these instances sensation of " first desire to void " is associated with rapid and full contraction of the bladder wall. As reflex on this scale is established, the sphincters cease offering resistance, which constitutes the habit element. Such a reflex may be established in maldevelopment or acquired irritative lesions of the spinal cord, most frequently in the lower portion. Increased rapidity of the reflex may occur by diminishing cerebral inhibition, hyper-irritability of the nervous mechanism, or increasing the strength of the bladder wall by lowering the voiding capacity. Infection plays its rôle in the latter effect.

Incontinence with the patient's knowledge is associated with or follows urgency of urination. Tenesmus does not develop in the milder degree of irritation. This type of incontinence means an imbalance between the forceful contraction of the wall and resistance of the sphincters with the balance of power in favor of the bladder wall. A low voiding capacity brought about by infection of the bladder, urethra, or both, or by hyper-irritability of the nervous mechanism causes it.

Other factors influencing incontinence are: Intake of fluid (greater in the daytime); ratio of output of urine day to night (three day to one night); loss of volume of water through the skin, that is, winter and summer influence; position of the body (erect by day, with the weight of fluid more directly over the orifice than when horizontal at night); alterations in intra-abdominal pressure (bending, talking, et cetera); reflex from other pathologies (pelvic to teeth); psychic irritability of day as compared with sleep at night. All these are accessory factors which should be analyzed in each case.

Normally the sphincter resistance has a sufficient balance of power to resist any unusual bladder-wall contraction. Furthermore, it has sufficient resistance to cause a degree of stimulation by the gradually increasing intracystic pressure sufficient to awaken the patient. At times, due to hyper-irritability, the bladder is in considerable contraction before the patient awakens and the act of arising and attempting to reach a vantage point for voiding may cause further bladder-wall contraction above which the sphincters cannot resist and a small amount of urine will escape, a sufficient amount only to decompress the bladder temporarily and to stop its involuntary contraction. If, under such conditions, the bladder empties completely, an abnormal mechanism is in control.

Night frequency in early prostatic hypertrophy is due to the thickening bladder wall compensating for the obstruction. The thicker-than-normal wall maintains an involuntary contraction until the constant though mild consequent stimulation awakens the sleeper.

Stream. In voiding, a slow *start* denotes deficient expulsive force either with or without change in the sphincteric resistance.

(1) Fibrous, adenomatous, or malignant changes involving the bladder outlet in that part traversed by the trigonal muscle in its attachment to the posterior urethra may cause a slow start due to difficulty in depressing this point sufficiently to allow urine to flow into the urethra, and so initiate and maintain the total micturition reflex. Obstruction may further be due to angulations of the urethra in forms of prostatic change so that compression of the lateral walls of the urethra by the fibrous or adenomatous mass takes place. In obstructions caused by stricture or enlarged prostates which have gradually increased their resistance, the start diminishes with the bladder-wall decompensation. At a certain stage in this process, however, the bladder wall retains a sufficient balance of power to start the stream with dispatch *excepting* when overdistended and so thinned to a bladder-wall expulsive power below sphincteric resistance. At this stage the patient will state that the start is satisfactory excepting if he or she goes long without voiding, particularly on arising, but after this they have no difficulty. Further, in bladders with normal

central nervous system we often have a stream that starts and stops several times in one voiding due to an irritable urethra spasmodically shutting off the outlet, or to a failing bladder wall.

(2) In neurogenic bladders a slow start may be due to:

1. Inability to depress the urethra (pudic nerve, levator ani action).
2. To a spastic sphincter (irritative nerve lesion), most often associated with spastic lower extremities.
3. Anesthetic pudic, either a pudic nerve neuritis, peripheral, frequently seen in diabetes and postpartum and in degenerative lesions such as tabes dorsalis and spinal cord pathology.
4. Primary autonomic alteration which is not diagnosable.

A residual urine in a neurogenic bladder accumulates either back of a spastic sphincter, in which case the changes in the bladder wall are quite comparable to those back of an obstructing prostate, or it accumulates as a result of lack of sensation. This sensation, in all cases, assumes a threshold point above which the bladder will empty. If the bladder is content to retain even a small amount early in the disease it means that the inherent function of the bladder " to empty itself " has ceased. The weight and volume of this residual urine, as well as its bulk, thin the bladder wall and the voiding capacity decreases as the elasticity (that is, extent of excursion of the muscles) decreases. This means an increase in muscle decompensation. The irritability decreases because of the pressure anesthesia of this weight of fluid and decreases even more rapidly than in myogenic cases.

The *flow* of the stream permits the same deductions, excepting that the voluntary sphincter has at least approximated its proper position though it may cut off and on again as mentioned above, and the most difficult point in expulsive force has been overcome, that is, the beginning of flow with the then distended wall.

Usually a weak flow is associated with a slow start, the exception being that the passage of a small amount of urine calls attention to a weakened flow which may be due in part to an obstruction the degree of which would not be noticeable if a larger bladder capacity were present. Such a condition is found in urethral strictures and early prostatic hypertrophies with an associated bladder or urethral infection and irritability.

The *stop* of the stream varies chiefly with the absence or presence of a residual urine or the point in bladder-wall compensation occurring just before a residual urine accumulates. Normally the bladder empties down to the last two or three cubic centimeters, at which time the viscus assumes a " Y " shape, the convexity approaching the internal sphincter. At this point the wall ceases its contraction; the urethra, by a pumping action (skeletal muscles, pudic nerve) associated with retained trigonal muscle contraction, emptying the remaining small amount. Terminal dribbling, the alternate of normal termination in spastic cases, is brought about by irritable sphincters closing against insufficient bladder-wall force — with or without a residual urine present.

In cases of severe myogenic decompensation, that is, a large residual urine, distortion of the outlet often permits more urine to run into the posterior urethra and excite the micturition reflex again and again. This can only be stopped by allowing the dependent urethra to empty passively after the desire to void has ceased. In similar neurogenic residuals a relaxed urethra with even a bag-like bladder may do the same thing but without the associated desire to void, as closure of the internal sphincter and the tone of the outlet are defective.

In strictures, a dilated urethra back of one may furnish the only imperfectly drained source of supply for terminal dribbling when a fully compensated bladder wall is present.

MYOGENIC BLADDER

Compensated and decompensated bladders. I prefer the term " myogenic " as differentiative from " neurogenic " and indicating that the alterations in bladder function are primarily in the muscle secondary to a physical obstruction such as urethral stricture or prostatic enlargement. Such muscle changes are at first compensatory — an enlargement, possibly some multiplication, of the individual muscle cells. Then, if the obstruction continues, decompensation occurs by stretching the muscle cells and so thinning and weakening them. A partially irreparable muscle decompensation, by the laying down of fibrous tissue between the muscle bundles, may rarely occur. Decompensation of the wall of the bladder requires other considerations, however, particularly before a marked clinical degree occurs. These considerations are, that in a distended bladder the same amount of muscle surrounds the large volume of water as surrounded the normally smaller amount which, of course, means less expulsive power per unit of fluid. If the resistant power of the sphincters exceeds the contracting force of the distended wall, *an acute decompensation*, that is, acute retention of urine, occurs. At times this may be overcome by a single catheterization.

Nerve changes in primary myogenic bladders. The bladder empties at a more or less constant pressure in a given individual. This intracystic pressure, in emptying a full bladder, starts low with the stream rather weak. As the urine empties the wall thickens and the stream increases in force. There is, therefore, no single intracystic voiding pressure. It varies with the quantity of fluid to be expelled and the status of the bladder wall and sphincters. If the normal voiding pressure be raised by obstruction, that is, the bladder wall gradually thickened to overcome an obstruction to the outlet, and if there be no degree of clinical irritation to urethra or bladder, there will occur a certain frequency with slight urgency of urination at some point in this bladder-wall thickening. This is due primarily to the increased suddenness and forcefulness of bladder-wall contraction when the micturition reflex is started. Long-continued intracystic pressure increase brought about in this manner is gradually compensated for by the intracystic pressure itself causing a diminished irritability of the bladder wall, a form of physiologic pressure or block anesthesia. This produces a type of *decompensation* which we may term "physiologic." It has more lasting qualities than a simple acute decompensation, and back of it, in almost every instance, is a hyperplasia of the bladder-wall muscle.

Residual urine. The next step is that, even with the higher intracystic voiding pressure, fluid in larger amounts is allowed to accumulate in the bladder due to the physiologic anesthesia. This larger amount, by distention alone, gradually continues the decompensation by: (1) weight of fluid adding to the pressure anesthesia and (2) the thinning wall losing force. For a time now frequency and urgency may disappear and still the bladder will empty completely but it will not be long until the factors analyzed here will bring about or allow a small amount of urine to remain in the bladder after voiding. Thus begins a residual urine.

Late decompensation. Increasing residual urine is the first factor in later serious damage to the bladder wall by distending the bladder more and more and through the vicious circle of increasing pressure anesthesia. If a cystitis occurs in a decompensated bladder the voiding reflex is accelerated, first by the irritated mucosa which resents the weight of fluid and then by the heightened urethral reflex. The frequency thus established causes a smaller bladder capacity and the infection irritability maintainance of this thickened wall depends upon the state of the bladder wall when it occurs. In certain instances the residual urine may disappear for a short time.

Fibrosis. Intramural fibrosis, Hunner ulcer[28], solitary ulcer. Symptoms are not constant with this disease but vary with the location and degree of the intramural fibrosis, psyche response, associated conditions of the bladder wall, central nervous system, and degree of infection. Linear or stellate fibrosis, multiple or single, on the lateral walls or dome are favorable from the standpoint of prognosis. Physically they interfere with the equal distention or elasticity of the entire bladder wall and, at the limit of the scar distensibility cause a stimulation of the nerve terminals and initiate the reflex of micturition. Such fibrosis, if not too serious in degree, can be increased in elasticity by slow dilatation and the prognosis bids fair. Complete emptying of the bladder just prior to catheterizing for distending it, or, if the level of the incoming fluid is high (three or four feet above the patient) the onrush will be sufficient to set the bladder wall in resistance. (In cystometric curves this resistance is easily noticed and measured). If, however, the fluid level from which the filling is to occur is an inch or two above the level of the bladder and gradually raised by hand without attracting the patient's notice, distention is usually more successful.

Pericystitis. Areas of fibrosis about the bladder are not diagnosable with a degree of accuracy sufficient to permit of cystometric interpretation. There are too many reflexes which symptomatically suggest a pericystitis. We would expect quite the same analysis as in an instance of solitary or Hunner ulcer or intramural fibrosis with less irritability.

Whether the stimulation of terminals of the autonomics in the bladder wall is directly in the mucosa, submucosa, or by pressure within the muscularis is not sufficiently determined.

As in intramural fibrosis, the amount of fibrous tissue, and its placement outside the bladder wall, could alter the symptoms so variably that each would present a problem to be analyzed on a basis of alteration from the normal mechanism of urination.

Prostatic hypertrophy. No two prostates, in their obstructive change, were or ever will be alike in size, shape, consistency, placement of the greatest obstructive points in reference to the internal sphincter, or in degree of infection. If the bladder wall could compensate forever to any obstruction, without damage to the kidneys because of pressure or infection, or to the general economy through pain, loss of sleep, worry, nerve, and toxic alterations, then prostatic enlargement would have no clinical significance. The wall of the bladder, therefore, becomes the intermediary between the obstruction and the kidneys and general economy. Alterations in the wall of the bladder may be rapid or slow or may become semi-stationary at any phase in the progress of the obstruction, providing its resistance to bladder-wall expulsive power is overcome. The changes obey the normal physiologic laws of compensation and decompensation of smooth muscle, providing no nerve pathology or anatomical anomaly be present at the onset.

The neurological phases to be considered. A disturbed psyche is an individual problem and is often associated with fear of carcinoma, fatigue, infection, and renal damage. Sleep is influenced by frequency of urination or bladder incontinence and the marked disturbance of a dysuria.

Associated pain is of three types: (1) Backache — increased tone of the heavy back muscles which is reflex from increased prostatic intracapsular tension. In this, infection plays an important rôle and mild prostatic massage may help. (2) Metastatic infection, myositis, periostitis. (3) Toxic neuritis.

Lateral or commissural lobes, located in their greatest enlargement near the internal sphincter, cause less change in the reflex of urination than do deep urethral adenomatous nodules backed by a thickened, fibrous, slowly yielding prostatic capsule. The latter cause greater pudic nerve stimulation.

Carcinoma of the prostate, in its effect on the bladder wall, differs from benign hypertrophy in its more rapid involvement and its metastasis. In bony metastases the associated pain is most often backache due to reflexly contracted or partially fixed muscles or pain referred to the back or lower extremities. Metastasis may alter the innervation of the bladder wall by involvement of any of the three sets of nerves.

Urethral stricture. Urethral stricture, with associated urethritis, depending upon its type, location, duration, and the individual lower urinary tract abnormalities, brings about alterations in the bladder wall similar to those outlined under obstructions and urethritis.

The only neurological phase particular to strictures is the marked likelihood of an associated urethritis with or without prostatitis or seminal vesiculitis, the reflexes occasioned by these changes with, probably, a gradual bladder-wall decompensation.

Urethritis of mild degree reflexly increases frequency of urination, while a urethritis of serious degree occasionally retards frequency until a secondary cystitis develops. This retardation seems to be a protective psyche-sympathetic reflex to protect from the passage of urine over the sensitive urethra.

Seminal vesicle pain is most often reflex from their over-distention and is located in the sacroiliac region. Renal pain in seminal vesiculitis may be due simply to breaking of the ureteral peristaltic wave through the juxtaposition of ureter and seminal vesicle, or to inflammatory changes of the latter involving the ureter. Pain of this type suggests renal colic.

Treatment of myogenic bladders with normal central nervous system. Analysis must be made from the standpoint of bladder-wall compensation or decompensation and directed to the reëstablishment of normal balance between sphincters and bladder wall with as little trauma as possible, considering trauma from the standpoint of self-infliction to the mucosa of the bladder or urethra by spasm or by catheter or surgery. Further, continued stagnation of urine, allowing undue multiplication of organisms, is all-important, particularly in the presence of trauma.

In well-compensated bladders, that is, bladder-wall strength exceeding an increased sphincteric resistance, a catheter is most likely to traumatize. In some instances the powerful wall, in its attempt to expel a retention catheter, will actually "chew" on the end of the catheter. In these cases a period of some bleeding and pain (which we describe as "the catheter being not well borne") occurs before the bladder mechanism adjusts itself physiologically. By this retention catheter, we have further strengthened (catheter compensation) an already hypertrophic wall. Removal may, therefore, place the balance of power in favor of expulsive force, in which case residual urine of varying degree may disappear and the start of the stream, as well as its force, improve. However, if the obstruction is not removed the wall will in time again decompensate in the presence of this trauma and infection, to the detriment of the patient. The back pressure and the absorbability of the infection will be greater in a partially blocked, contracted, and freshly traumatized bladder and injured urethra. Surgery which allows contraction without free drainage carries the same considerations. In all instances the denudation of absorptive areas should be protected from high intracystic pressure and associated heightened reflexes causing trauma by too forceful rubbing of opposite urethral or bladder walls, until such areas are again covered and the degree of infection reduced. As an example, in a one-stage prostatectomy some cystitis and infection of the prostatic capsule area occurs. If the suprapubic bladder wound closes or bladder drainage becomes imperfect before this area is covered, urethral or bladder irritability causing pain and frequency, with spread of infection — thrombophlebitis, seminal vesiculitis, local cellulitis, epididymitis, as well as bacteremia with its possible secondary infections — are apt to occur. The irritable postoperative prostatic capsular area increases the pudic nerve (urethral) bladder reflex, although in these instances the afferent paths may be pelvic as well as pudic. With free bladder drainage and removal of packs, hemostatic bags, et cetera, from this area, the bladder lies quiescent. Closure of the bladder, contracted by the long emptiness, for a time exerts an unusually high initial voiding pressure and may require opening to prevent unpleasant reflexes and increase in bacterial absorption. Final closure means sufficient healing of the suprapubic wound to withstand any bladder-wall expulsive force, a well-timed reflex of micturition, beginning return of the bladder wall to its normal status — that is, the return of a satisfactory balance of power between bladder wall and sphincters. Alterations in closure can be interpreted on this basis, and the reason found in remaining mechanical, or nerve, complications.

The two-stage suprapubic prostatectomy is slower in cystostomy closure than the one-stage, due, in part, to the longer standing of the bladder-wall contraction.

Transurethral surgery, with its resultant trauma in obstructive lesions, again can apply these principles to decrease shock and local, renal, or generalized infection. The compensated bladder back of an obstruction is reflexly stimulated by the urethral trauma and further contracted by a retention catheter. Often the sphincter resistance is not lowered sufficiently to permit the bladder wall to return to normal and an infection is spread by the not completely effectual though powerful bladder-wall contractions.

Intermittent catheterization. The use of the catheter meets with complete success so often, and fear of its use in bladders with residual urine has been taught for so long, that application of this type of treatment requires analysis on a physiologic basis. Our first consideration is to determine the status of the bladder-wall strength versus the sphincter resistance. If a residual has not developed in a bladder back of an increasing urethral obstruction, catheterization can do nothing other than traumatize the bladder and urethral walls. Trauma plus a preëxistent infection may mean severe infection manifestations. Repeated catheterizations through the slightly traumatized areas of previous catheterizations, with their resultant increasing localized infection, will mean cystitis and urethritis with changes in the micturition reflex, depending upon which portion of the membrane (bladder, urethra, internal sphincter) mechanism is most irritated.

A single catheterization in the presence of a residual urine is not dangerous, in my opinion. It is *repeated* catheterizations which cause uremia, not by means of a sudden release of bladder pressure with resultant *inertia* damage to the renal glomeruli, but by means of infection which, superimposed on a back-pressure of some degree, is sufficient to cause symptoms of renal deficiency. Without this back-pressure damage the toxic renal change would not be sufficient in most cases.

The damage resulting from intermittent catheterization, from the standpoint of bladder physiology, depends again on the type of obstruction and the balance of power between bladder wall and outlet. In general, it may be said that if the obstruction is great the bladder wall "lies down " quickly, but if the expulsive force approaches in strength the resistant power of the sphincters the bladder musculature fights on and on in its efforts to win by growing ever stronger.

How can we account for the rare instance of self-catheterization over a long period of years, in some instances with no aseptic care of the catheter? Its answer is a markedly decompensated myogenic bladder or a neurogenic bladder with low muscular tone causing a mild degree of trauma and absorption. A high resistance to infection is necessary. In neurogenic bladders of low tone there is a greater thinning of the mucosa, with diminished vascularity, than in severe myogenic decompensation. Catheterization in the presence of a large residual urine, not infected, has long been conceded to offer a bad prognosis and should be considered so if the residual urine does not disappear by one catheterization. Otherwise an infection is " locked in " an organ with no acquired immunity and the fresh cystitis will not only assist in absorption but will increase the forceful contraction of the already compensated wall. If a catheterization, by contracting and thickening and thus strengthening the wall, places the balance well on the bladder-wall side, its repetition offers little to fear in most instances.

Retention urethral catheter. The longer a retention catheter is in the more marked becomes the associated " foreign body " infection which reflexly increases the tone or " set " of the empty thickened wall. Success of the procedure again lies in evaluating the balance of power between bladder-wall strength and outlet resistance. This is done by a determination of the residual urine. If, after the removal of a retained urethral catheter, there remains a large residual urine we may consider that it is locked in an acutely or subacutely infected bladder capable of undue strength of contraction. Nothing could be more favorable to generalization of bladder or urethral infection.

Either form of catheterization may be equally advantageous or dangerous in myogenic or neurogenic dysfunction on a basis of these facts, adding thereto the usual bacteriological considerations of virulence of the organism versus resistance of the patient.

NEUROGENIC BLADDER

Terminology. In addition to " neurogenic bladder " this includes " tabetic," " atonic," " paralytic," and " cord " bladder. As the nerve function of the bladder is intimately concerned in myogenic bladder, so is the musculature of the bladder and sphincters intimately concerned in neurogenic bladder. Cystometrically, normal individuals vary markedly in their bladder capacity and it seems probable that in some individuals there is an inherent low intracystic pressure with consequent large capacity fitting a Sympathetic Over-balance type, while others show a high intracystic pressure and low capacity, Parasympathetic Over-balance type or Vagotonic type. In studies of neuropathic bladders, however, it is extremely difficult to diagnose Sympathetic and Parasympathetic Over-balance bladders. Such *types*, however, may be considered for purposes of classification; that is, the sympathetics (nerves of filling which relax the wall and close the internal sphincter) are more powerful than the parasympathetics (nerves of emptying which contract the wall and open the internal sphincter) or vice versa.

Outside of these, the pudic nerve stands voluntary guard in its control of the voluntary muscles constituting the external sphincter. Loss of pudic nerve function makes it impossible to manipulate the external sphincter, which constitutes a mild obstruction, while marked pudic nerve irritability spastically closes the external sphincter.

Results obtained by study with the cystometer showed[52] that:

1. Epinephrin in small doses causes contraction of the bladder and in large doses relaxation. (Sympathetic stimulation.)
2. Pituitrin produces increased bladder-wall tone. (Direct muscle action.)
3. Atropin acts as a parasympathetic inhibitor.
4. Pilocarpin and acetylcholin act as parasympathetic stimulants.

With regard to epinephrin and pituitrin the experimental results corroborate clinical experiment. I have seen hypopituitary types of individuals who show a decreased bladder capacity upon administration of pituitrin and asthmatic individuals who developed a marked decrease in expulsive power upon constant administration of suprarenal extract.

Myogenic factors in neurogenic bladders. In association with neurogenic bladder we must consider certain muscle-wall changes: (1) Thinned, relaxed, and relatively avascular in the Hypoesthetic type; (2) Contracted and congested in the Hyperesthetic type or in the type which is secondary to an altered outlet (sphincter) innervation, with or without alteration in the nerve supply to the bladder itself. Decompensated neurogenic bladders compensate slowly and transiently upon catheterization, either intermittent or retention.

The rectal sphincter. Spastic voluntary bladder sphincters usually show spastic voluntary rectal sphincter, both being in control of the pudic nerve (levator ani). The autonomics of the internal rectal sphincter are first to fifth sacral, only slightly more extensive than the internal bladder sphincter which is chiefly second sacral to fourth sacral.

When one is relaxed secondary to a cord lesion, with rare exceptions, the other sphincter is relaxed. Disassociation of tone in these sphincters is occasionally seen, however, most frequently in extra-dural lesions[55].

Psychic retention of urine. Inhibition of urination is cerebral in origin and, while the act of micturition begins with a voluntary depression of the posterior urethra associated with contraction of the trigonal muscle to allow urine to stimulate the pudic nerve in the posterior urethra, this voluntary act, in itself, is not sufficient to complete the act of micturition. The act requires release of cerebral inhibition. In some individuals this release is impossible excepting under conditions to which they have become accustomed, namely, being alone. Counter-emotions, such as fear, anticipation, et cetera, prevent release of the cerebral inhibition and, as a result, we have a psychic retention. Psychopathic states are incontinent or continent compatible with the vagaries of the mind.

Hysterical bladders show marked functional varieties. In some, a retention of up to 1,000 cc. may occur or exhibit itself in a residual urine, only to be absent at the next catheterization and to reappear when least expected. Large residual urines are associated with transient imperception of the pain of overdistention.

Malingering. The varying degrees of bladder sensitivity do not occur, as in hysterical bladders, the amounts voided being more normal but often a residual will occur at one trial and not at the next. The symptoms are not compatible with the analysis of bladder function in either case and, so far in my observation, malingering in such manner is closely akin to psychic alteration describable clinically as hysterical bladder.

Fear is often associated with involuntary emptying of some of the bladder contents and is due to a release of cerebral inhibition. It is often associated with the Vagotonic type or to a diminished resistant power of the sphincters.

Voluntary retention in normal bladders becomes possible through the development of a mild degree of pressure anesthesia and bladder-wall thinning. In the process of accumulating such an amount as 800 to 1,000 cc. the individual passes through several stages of imminent expulsion which, being overcome, leaves the individual surprisingly comfortable.

Reflex stimulation from anal fissures, infected anal crypts, skin lesions about the perineum or genitalia, gynecological pathologies, et cetera, cause alterations in the smooth functioning of the bladder. A markedly traumatic dermatitis of the perineum associated with pruritis may cause frequency through reflexly causing spasm of the voluntary sphincter muscles. Such frequency leads to the voiding of small amounts which alone, at times, will account for a weaker stream in men of the fourth and fifth decades of life. This condition is encountered in a simple prostatitis and seminal vesiculitis.

Masses in the low rectum and certain fibroids, located below the bladder floor, interfere with the initiation of voiding by interfering with depression of the internal sphincter and urethra. Inflammatory pelvic masses resent the pressure of the distending bladder and cause a reflex frequent voiding which, in itself, promotes greater frequency.

Trigonitis. Trigonal irritability — from a physiologic viewpoint irritation of the trigone — is either part and parcel of a cystitis or it is a passive congestion associated with a spastic bladder outlet. If a cystoscope is introduced into a normal bladder we note a smooth, pale trigonal mucosa. If, however, we leave the instrument in for two to five minutes, we note a passive congestion beginning at the internal orifice and gradually spreading up over the trigone and about the ureteral orifices. In passive congestion of long duration, due to the vessels being partially shut off by spasm rather than by the cystoscope, thickening of the mucosa, a "sheep's wool" trigone, and later bullæ formation over the trigone and internal sphincter may occur.

Treatment of trigonitis. This involves, first, an analysis of the etiology of the cystitis, in which case trigonitis, as a clinical entity, does not exist. Secondly, it requires analysis from a reflex standpoint of the cause of the hyperplastic, contracted, internal sphincter. The contraction of the internal sphincter denotes a bladder-wall contraction as it is but a part thereof. Dilatation of the urethra and hydraulic distension of the bladder are suggested symptomatically. In some instances a low-grade bacilluria may be found to exist in a sparkling clear urine. In such instances the cause must be determined and treated.

Peripheral nerve lesions involving the bladder may be toxic, bacterial, alcoholic, traumatic, or diabetic. In all, an added infection often plays an important part. Such lesions, from observations so far, are entirely pudic nerve neuritis. The sphincters may be relaxed and sensation to filling and intracystic pressure is lowered, or the reverse may occur.

Treatment. The neuritis disappears slowly. It is all important to treat the associated urinary infection. Search for possible reflex or primary cause.

Central nervous system lesions. If the pathology causing alterations in bladder function be of either the spinal cord or brain, it cannot be classified on a basis of disease but rather on a basis of the location and extent of the involvement. For example, many central nervous system lues present no bladder symptoms. This is, of course, equally true of cord tumor, brain tumor, lesions secondary to infections, or to anemias.

Cerebral. In the larger percentage of localized destructive brain lesions we have either loss of inhibition or an inability to coördinate to initiate urination. In both instances the effects are usually transient. Such a phase may be determined by analysis of past symptoms — for example, a period of frequency of urination due to loss of inhibition, or an inability to void due to a loss of coördination. Postoperative results of either type are occasionally seen though more frequently such types are associated with cerebral hemorrhage or accidental trauma.

Paresis may or may not be associated with a tabetic bladder. In paresis the incontinence often seen may be only an inability to choose the proper time and place to empty the bladder, as in other mental diseases.

Spinal cord pathology. In general, spinal cord lesions (Sir J. Thomson-Walker[64]) affect the innervation of the urinary bladder according to their location, extent, duration, and the degree of pressure upon the cord. Early pressure causes a hyper-irritability; a long continued pressure a hypo-irritability of bladder function. At the present stage in our clinical analysis of cystometric readings and interpretation of symptoms, we are confronted by some lack of information or, at least, there is no definite agreement on all points. Recognizing these facts I have, however, used the following rules satisfactorily for such analysis:

1. Stimulation of the sympathetics will cause: (*a*) increased capacity; (*b*) decreased voiding pressure; and (*c*) decreased irritability, that is, over-action of the nerves of bladder filling.
2. Stimulation of the parasympathetics will cause: (*a*) decreased capacity; (*b*) increased voiding pressure; and (*c*) increased irritability, that is, over-action of the nerves of bladder emptying.
3. Paralysis of either set of autonomics will result in an over-balance of function in favor of the remaining set.
4. Stimulation of the pudic nerve will cause a spastic or actively blocked external sphincter, eventually resulting in a myogenic decompensation of the bladder wall.
5. Paralysis of the pudic nerve will also block the external sphincter, passively, in that it cannot be depressed to allow the bladder wall to expel its contents.

The diagnosis of autonomic imbalance can only be made clinically, not actually or anatomically. Above all, the secondary myogenic factor is important in the diagnosis.

With these ideas in mind we consider spinal cord tumors[55] intra- or extra-dural and judge the degree of early irritation or late damage from an analysis of symptoms. For example, if a patient is unable to void, has a tightly distended bladder with a spastic external sphincter, bladder and rectal, and with no other obstruction as determined cystoscopically, we feel that it is an early involvement of the pyramidal tract. Later, an anesthetic bladder with thin wall, diminished vascularity, and a large residual urine may develop. In this later case a *first* cystometric curve would be neurogenic — low pressure, large capacity, and diminished sensations — and one would feel that the parasympathetics are *out*. But the *second* curve at the same sitting would show a good increase in the muscle tone of the wall with some increasing irritability. This would diagnose an irritative lesion, spastic outlet with secondary bladder wall (myogenic) decompensation. If, on the other hand, the nerve lesion were destructive, the stimulation of repeated filling and emptying would not return the physiologic picture to the normal in the second cystometric filling taken at the same "sitting." Alteration in the long tendon reflexes and complete neurological examination are most important in each instance.

Location of tumors. As Head[24] pointed out in 1893, a cord lesion above the ninth thoracic permits an accumulation of urine — residual — with automatic emptying of the bladder. This means that sufficient innervation remains below the ninth spinal segment to allow the bladder to go through its reflex mechanism, only failing in its duty of completely emptying itself on account of the muscular decompensation. Lesions above the ninth, compatible with life, fall into this classification but those below, as far as the fifth lumbar spinal segment, affect that portion of the bladder innervation which has to do with the filling (sympathetics). Thus, from the ninth dorsal to the fifth lumbar spinal segments we analyze the lesion on the basis of duration, extent, pressure, et cetera, of the cord pathology. From the first sacral to the fourth sacral spinal segments (parasympathetics) we have, from the standpoint of the autonomics (pelvic nerve), either irritability or destruction of the nerves of bladder emptying. The pudic nerve is also closely associated with these segments and its action will also be affected, as has been outlined.

Types of tumors. To attempt to classify or delineate the extent of a cord tumor or to signify its type is a clinical guess, if based solely upon an interpretation of bladder function. However, it is possible to determine the status of the altered function and so properly institute treatment. Traumatic cord lesions, with or without hemorrhage, do not need special consideration in that they follow the same arguments of extent, duration, location, and degree as outlined. However, in this type of lesion it is well to recall that the bladder muscle, as we see it at the time of injury, will alter markedly as time goes on. A myogenic decompensation may occur back of a spastic sphincter and so ultimately lead to a paradoxical incontinence, or a decreased sphincter tone may lead to an imbalance in favor of the bladder-wall expulsive power — that is, incontinence. A reflex or automatic bladder may develop.

Spina bifida causes a most bizarre variety of neurogenic alteration in bladder function ranging from none to a spastic or paralytic outlet or bladder wall. Most frequently the voluntary sphincter is primarily involved with myogenic changes back of it. An analysis of the type and degree of myogenic change frequently points the way to advantageous treatment of what very frequently is a form of urinary incontinence. On account of the anomalous innervation, neurological surgery for relief should be undertaken with great caution.

Tabetic bladder. The usual tabetic bladder is one of low intracystic pressure, increased capacity, and decreased sensation and, in late stages, is associated with myogenic bladder-wall decompensation of varying degrees due to a decreased sensation permitting an overdistention with attendant bladder-wall weakening and accumulation of a residual urine. Bladder infection is much less important in these cases than in myogenic decompensation back of a hypertrophied prostate, et cetera. Evidence of destructive nerve changes may occur, — a Charcot knee, for example — associated with an early irritability of the bladder. Many tabetics present no clinical bladder findings. The irritative bladder in central nervous system lues is much less frequent than the one usually described as tabetic and, further, it is a passing phase in many instances, the meningitis phase.

Luetic pachymeningitis causes changes in bladder function. Of course, it is very rarely possible to have a cystometric examination suggest the diagnosis as other luetic lesions are so often associated. Such a lesion can alter the function by a local nerve disturbance. Other symptoms — gastric crises, — occasionally would suggest it as primary in the *bladder* dysfunction, sympathetic overbalance type.

Senility. The bladder mechanism is impaired, and most often is attributable to the altered sensorium. No residual occurs in a senile bladder. Often the rectal sphincter is so relaxed in senility as to suggest a cord bladder.

Treatment. This method of considering spinal cord lesions in their effect on the bladder renders ineffectual and uninteresting any blanket statement regarding the use of a catheter, open operation, or manual expression in so-called cord bladders. Treatment is never indicated, either open operation or catheter drainage, until a large bladder retention requires relief from the standpoint of pain, renal back-pressure, or infection.

The first consideration is as to the prognosis of the nerve lesion. If it will recover our duty lies in protecting the kidneys from back-pressure as well as from infection during the period of bladder dysfunction. Treatment then divides itself into: open operation, catheter drainage either continuous or intermittent, manual expression, or watchful waiting with the development of an over-flow bladder. Determination of choice is primarily made on the probable duration of treatment and considerations of the comfort and protection of the patient. From the standpoint of bladder physiology the primary consideration is to determine which is stronger, the bladder-wall expulsive force or sphincter resistance, and why.

1. A flaccid, weak bladder wall will not spread infection and, if neurogenic, compensates to a catheter very slowly.

2. A powerful, hyperplastic bladder wall, though dilated, will, when empty, cause trauma to its own wall by the catheter tip, with resultant pain and infection dissemination.

3. A flaccid outlet with bladder-wall compensation behind it is temporarily fine but, in time, will cause a contracted fibrosed wall which cannot be corrected.

4. An irritable, spastic sphincter will not comfortably accommodate a catheter and further, by its trauma, will endanger spread of infection, partially via the urethra, prostate, and seminal vesicles. It will eventually dilate the bladder.

Catheter drainage is preferable in a flaccid bladder wall which will compensate slowly. The choice of continuous or intermittent catheter drainage depends upon the amount of residual urine, convenience, and degrees of bladder-wall decompensation, toxicity, and discomfort.

Open operation is undesirable with a spastic outlet for, as a rule, the cystostomy wound will close with difficulty. However, in certain degrees of increased sphincter resistance in which intermittent catheter drainage causes trauma and the increased degree of infection is of importance, a cystostomy is preferable and may be closed by the use of a retention urethral catheter. Cystostomy is desirable when the expectancy of life is not great and where there is marked sphincter tone.

Manual expression fits those cases in which there is an actual or relative decrease in bladder tone. In these cases a residual remains behind.

Automatic bladder actually means one in which no stimulation or pressure is used. It is an involuntary emptying of varying amounts of bladder fluid. Not all of the bladder contents is emptied. In all instances, however, the automatic act is reflex from some visceral or surface stimulation if nothing more than contact of the skin with the bed or bed covers. It occurs in high cord lesions most frequently, as the higher the lesion the more extensive may be the stimulation on or within the body to institute a reflex micturition. In lower cord lesions (low lumbar or sacral) the nearer must the peripherally stimulated nerve supply approach the spinal segments supplying the bladder to cause the reflex.

It is very suggestive that the cases in which manual expression is most successful are those responding reflexly to the stimulation of the pressure, in part at least, rather than entirely to the direct pressure.

In certain thin individuals one can almost grasp the distended bladder but in many others the pressure is directed to increase the intra-abdominal rather than the intracystic. To raise intra-abdominal pressure to any degree it is necessary to fix the diaphragm, abdominal wall, and perineal muscles, and to fix the latter means to contract the external sphincter muscles. The muscle status of such bladders is determined by the amount of residual urine and the tone of the bladder and rectal sphincters ascertained by catheter and digital examination respectively.

The time of occurrence of a reflex or automatic bladder after injury is important and calls for delay in that a period of flaccidity is followed by a more permanent period of muscle spasticity with irritability of all the reflexes. Consequently, an automatic bladder often develops some days or even weeks after the spinal cord injury.

Infection in automatic bladder. The cord injury which permits the development of an automatic bladder, or one in which the contents are partially expressable by hand, is fortunate from the urinary standpoint as spread of infection is less likely to occur though simply the presence of a residual urine may precipitate it. To this end, in cord injuries with urinary retention, watchful waiting for the development of the reflex or of a paradoxical incontinence (overflow bladder) is desirable. In some, however, previous to such development an acute cystitis or cystopyelitis, with or without back-pressure symptoms, and a rise in blood non-protein-nitrogen occur. In infected bladders with residual urine, with or without a diminishing kidney function to which a pyelonephritis is secondary, drainage of the kidneys can best be accomplished by constant removal of the bladder residual, thus reducing the degree of cystitis. Therefore, in certain instances it becomes desirable to catheterize before an automatic bladder can be accomplished.

Many automatic bladders are infected, the organism being of low virulence and the musculature atonic, and so they exhibit no symptoms of it either locally or generally. A markedly spastic rectal sphincter, while pointing to a spastic urinary outlet, does not preclude the development of a most satisfactory automatic bladder as this sphincter reflex may be hyperactive though functionally operating in harmony with the associated reflexes such as abdominal-wall compression and bladder-wall contraction.

Postoperative retention. The factors to be considered are:

1. Psychic retention, fear of pain, or inability to coördinate to initiate the act of urination. This may be due to shock, drugs, or to some one being constantly near the patient.

2. Position of the body. Any actual or relative raise of the floor of the bladder at or near the internal sphincter or of the posterior urethra makes it more imperative to stand or even bend forward to start the stream. In this connection we must also consider cystocele, full rectum, fibroid, prostatic enlargement, and reflex spasm of the voluntary sphincter.

3. Simple overdistention due to hypnotics or analgesics and with a too large fluid intake at the same time often given subcutaneously or intravenously.

4. In this type of retention a low intracystic pressure with normal sensation occurs. When this abnormal association *persists after emptying* we have a Sympathetic Over-balance type of bladder. The reflex is afferent from the operative area involving those spinal cord segments sending the "nerves of filling" to the bladder (first dorsal to fifth lumbar). Low abdominal or pelvic surgery may be included in this classification as well as higher abdominal operations.

Perineal, vaginal, or rectal surgery frequently causes postoperative retention; so, too, does anterior abdominal work or diaphragmatic involvement as all these structures are involved in the voluntary muscular contraction when the intra-abdominal pressure is raised to initiate normal micturition. The patient, from a preconceived fear of pain may hesitate to permit this contraction, during which time the bladder overdistends. Surgery involving the region supplied by the sacral spinal segments from which the nerves of "bladder emptying" (the parasympathetics) come, is apt to result in an unusually persistent bladder retention, a parasympathetic inhibition. I believe that such a parasympathetic inhibition is most frequently due to a reflex spasm of the voluntary external urinary sphincter.

Treatment is intermittent catheterization when the post-operative retention demands it. The retention rarely lasts more than seventy-two hours and, in a great majority of instances, is corrected by the catheter compensation of one emptying. Otherwise correction of one of the other factors is indicated, such as sitting. The sitting (position of the body) does the important work although a warm pitcher douche may occasionally be of assistance in securing the necessary relaxation. Catheterization to determine the presence of a residual urine is desirable if symptoms of bladder dysfunction insist but it should not be used *before* such symptoms appear. Irritating drugs placed in the bladder offer benefit by the use of the catheter with which they are placed. Any drugs used by mouth, hypodermically, or intravenously must be directed toward improvement in the specific alteration, which is lost motor power with normal sensation.

Postpartum retention. While this type of retention is a clinical entity, it may be associated with the postoperative type of retention caused by the trauma of delivery, use of forceps, or surgical interference such as episiotomy, which type follows the course of perineal postoperative retention and such a bladder functionally exhibits a *low intracystic pressure and normal sensations.* In distinction to this occurs the specific type of postpartum retention — a bladder of *lowered sensations with raised intracystic pressure.* Such a state causes a high intracystic pressure and aids in bacterial invasion, lymphatic, hematogenous, or by direct ureteral regurgitation.

In pregnancy and at delivery the pudic nerve offers one place for compression, with a resultant physiologic nerve block, at the inner surface of the tuberosity of the ischium. Such a nerve block, depending upon its extent, can so lower the sensation of a " first desire to void " that a large amount of urine may accumulate in this spastic bladder before instituting sufficient stimulation to notify the individual of a desire to empty it. Further, the autonomic nervous system is free of interference and permits a normal myogenic compensation. Eventually this residual urine, by its physical presence, will lead to increasing stages of decompensation of the bladder wall and to larger and larger amounts of residual urine. The principal factor in the temporary pudic nerve block is not the total duration of labor but rather the length of time the child's head rests upon the pelvic floor. I do not believe that this nerve block can be ascribed to morphine-scopolamin as the diminished bladder sensation lasts as long as seventeen days in our experience.

Shutter[58] and Day[15] both find that pathological bacteria injected into healthy bladders have failed to produce infection in the absence of injury or of a residual urine. In pyelonephritis in pregnancy, therefore, added to the type, number, and degree of virulence of the organisms, the resistance of the patient and the pathological urinary factors not indigenous to pregnancy, one has to consider: (*a*) residual urine in the bladder, ureter, and pelvis; (*b*) its sudden release with the possibility of petechial hemorrhages developing in the urinary mucosa; (*c*) the trauma of, type and duration of delivery; and (*d*) the trauma of catheterization. A large percentage of infections are of the coliform group and are present before delivery. If there is an acute exacerbation following delivery, it is often associated with retention of urine in the bladder or upper urinary tract and is often brought about by improper management of this residual urine.

Treatment of postpartum pyelonephritis. The treatment of postpartum pyelonephritis or the pyelonephritis of pregnancy carries many of the foregoing considerations but obviously varies in that we are dealing with an ordinary pyelonephritis plus a retention in pelvis, ureter, or bladder and, in some instances, a change in the innervation of the bladder.

The first consideration is to determine whether or not there is a bladder retention and, if so, the amount. If this is large, cystometric work suggests that it will continue from twenty-four hours to two weeks or more depending upon the change in the innervation of the bladder. With a large, infected residual urine, demanding removal, it would be folly to drain the ureter and kidney pelvis. Rather, constant bladder drainage to overcome the urinary stasis is indicated. In the majority of instances this will afford constant ureteral drainage as well, excepting, of course, the factors of marked ureteral and kidney pelvic wall decompensation, ureteral stricture, or stone, et cetera. Even an ureteral and kidney pelvic myogenic decompensation will, in some degree, return to normal with time and continued drainage of the bladder, in a large majority of cases.

The difficulty in handling residual urines lies in the fact that the patient is not conscious of fluid in the bladder and that, in a myogenic breakdown of the bladder, this can continue while the patient is voiding good amounts. In fact, the voiding of occasional separate large amounts, up to 900 cc., suggests pudic nerve anesthesia or pressure damage and an increasing residual urine in these cases.

When, following delivery, catheterization becomes imperative because of infection or overdistention or both, do so and note the amount and degree of infection of the urinary specimen, and the force with which it flows through the catheter. The pain of overdistention is peritoneal rather than pudic nerve sense of a desire to void. If the residual urine is large and there is a definitely diminished desire to void, good force to the catheter flow, et cetera, it is wise to leave the catheter in to decompress. This aids markedly in draining an infected kidney, and does not allow multiplication of the organisms in the stagnant bladder urine and their subsequent invasion into the body by mismanagement of this infected pool in its abnormally functioning container. Where there is no urinary infection and no back-pressure kidney damage, it is wise to allow the bladder to spill over until the function of the pudic nerve returns. If both postoperative and postpartum changes exist in the same bladder, one must determine the predominant change chiefly by noting the sensation caused by a large amount of urine, and treat conservatively awaiting definite developments requiring either continuous or intermittent bladder drainage.

Toxic retention. This is occasionally seen in extremely toxic individuals, with typhoid fever, for example. It is due to a lack of perception at the time bladder distention is occurring, after which an imbalance of power between the thinned distended bladder wall and the outlet, in favor of the latter, is established. One catheterization will readjust the balance as a rule.

Enuresis. Enuresis may be divided into day and night urinary loss, with or without the patient's knowledge, and with or without a normal central nervous system. The psychic factors vary from fear anticipation or hyper-irritability, possibly difficult to elicit from a child, to the most serious and definite of mental disorders. Each presents its problem from a psychoanalytical standpoint, but the bladder mechanism remains constant, the cerebrum its inhibitor. In each and every case a specimen of urine which has been in the bladder for three hours should be cultured and stained for organisms. In both males and females it should be catheterized if, as is often the case, the urine is sparkling clear but shows a few organisms but no pus on methylene blue stain. Such specimens, which have been incubated in the patient's bladder for fifteen minutes to one hour, will often be negative for infection.

The cause of enuresis sometimes lies in interference with inhibition. The depth of sleep occasionally is a factor but even then the inhibitory factor should be present.

Spinal cord disease, such as malformation (spina bifida), neoplasm, damage by trauma or infection, peripheral nerve lesion, toxic, alcoholic, diabetic, traumatic, and pudic nerve reflexes, are diagnosable by a close study of bladder function, as has been outlined previously in this chapter.

Habit is a great factor and offers the best prognosis if the cause of the onset of the habit can be removed.

Parasympathetic overbalance type of bladder — associated with pinpoint pupils occurs. In this type full contraction of the bladder is associated with a first sensation of desire to void. Atropin should help, but in my experience it fails. Treatment is hydraulic distension of the bladder with other usual management, such as control of fluid intake, wakening, et cetera.

Frequency of urination in itself establishes a vicious circle of greater frequency. To explain: an irritability (reflex or bacterial) causing the emptying of small amounts of urine frequently, means a stronger, contracted, thickened bladder wall with sharper contractions. Distention of the bladder wall or urethra with non-irritating solution will often increase the amount voided and so lessen the frequency of urination even with a mildly irritable reflex remaining.

If possible, the determination of voiding capacity and the presence or absence of a residual urine is indicated first. This, with the time of each voiding, will point definitely to the type of bladder dysfunction. A normal day voiding capacity, with persistent enuresis nocturia, points to an interference with cerebral control.

In a certain case of spina bifida occulta the enuresis began at about the time the young lady contemplated marriage. Cystometric examination showed a severe myogenic decompensation of the bladder wall with a mildly infected residual urine. Repeated catheterization brought back the tone of the bladder wall and although urgency of urination persisted (catheter compensation of a hyperplastic wall with neurogenic outlet block) the enuresis stopped. Such a condition would eventually go on to day incontinence. Each instance of enuresis offers an opportunity for analysis of the neurogenic and myogenic components of the urinary mechanism.

THE FEMALE BLADDER

Cystocele. Agreeing with the work of Van Duzen[62, 63] I believe that from a functional standpoint there are three types of cystocele: (1) those in which the trigonal muscle is divided near the ureteral orifices; (2) those in which the trigonal muscle is divided at or near a mid-point between the ureteral orifices and the internal sphincter; and (3) those in which the trigonal muscle is divided at the internal orifice. In all types the innervation is primarily normal but definitely involved, peripherally, in the secondary myogenic changes.

Considering type number one: if the trigonal muscle alone were injured, in a great majority of cases the function would, at least clinically, remain unchanged.

Considering type number two: a low-grade bladder-wall muscular compensation will, in most instances, overcome the effect of this damage.

Considering type number three: there may be, in such instances, no outward evidence of cystocele excepting that the urethra may extend forward a little, partially lacking attachment to the bladder floor. With a cystoscope in the bladder, viewing the internal sphincter margin at the most dependent point, one will see a high or thick internal sphincter musculature forming a deep, acute angle with the trigone. If now, the patient is asked to strain, as in voiding, this angle will deepen and the internal sphincter margin (at 6 o'clock) will be insufficiently depressed. In such instances a congestion with or without over-epithelialization of the trigone is associated. The symptoms are urethral, pudic nerve at first — that is, a desire to void often — urethral pressure pain immediately after voiding, and so a sense of incomplete emptying of the bladder. These sensations lead to the vicious circle of " frequency." The urethral symptoms are exaggerated by the loosened internal sphincter contracting upon itself, which often produces a hyperplastic, and further irritating, urethritis — reflex back, abdomen, and thigh pains.

The urethral floor, in not descending, becomes a myogenic obstruction further aided by the spastic sphincter musculature. A small residual urine (myogenic decompensation with back-pressure anesthesia) will accumulate occasionally, particularly associated with such factors as a large fluid intake or putting off voiding too long, leading to acute retention requiring single catheterization to return the expulsive bladder-wall force into control. This means that if type three is uncomplicated by greater tears we have an irritable bladder with spastic outlet and occasional accumulations of residual urine in a bladder of good compensation with symptoms corresponding.

Treatment is directed entirely toward returning the balance of function between resistant power of the outlet and expulsive bladder-wall force. This is as successfully accomplished in types number one and two by perineorrhaphy. If, on account of associated trauma of delivery, there is a marked visible cystocele or rectocele which has been satisfactorily repaired but without relief of all symptoms (infection or bladder function) it will often be found that the trigonal tear is at the internal sphincter attachment.

Uterine interposition operation particularly may be unsuccessful when type three cystocele is present. Anterior perineorrhaphy is often successful and should be undertaken with a full understanding of the existing state of the bladder and attempt to reattach sphincter to trigone by direct stitch.

The symptomatic treatment of type number three is urethral dilatation under anesthesia, which breaks the urethral reflex. In certain instances this will give fairly lasting relief. In some instances, even though the basic underlying factor remains it is wise to destroy the urethral tabs. If the tabs are small, however, the urethral trauma of their destruction hastens the return of the nerve reflex, urethral contraction. If the habit of frequency has been long established it may be wise to dilate the bladder slowly and carefully to a normal overdistention capacity (600 cc.), remembering that internal sphincter thickening means thickening of the musculature of the wall of the bladder.

Salpingitis causes frequency by reflex contraction of the bladder, and is protective to prevent pain of bladder distention.

Fibroids. The alteration in bladder function by such masses may be purely mechanical or it may be reflex, depending upon the size and location of the tumor. The pressure of a large mass upon the bladder wall causes a decreased capacity by destroying the smooth and even elasticity of the wall. The bladder is maintained in constantly increased tone. There is a painless hyper-tonicity if no infection is associated. This means frequency and some urgency of urination. Fibroids at or near the cervix, if of proper size and location, can raise the floor of the anterior trigone and prevent its depression in the initial act of urination. This constitutes a myogenic obstruction which is followed by the train of physiologic alterations in function dependent upon the degree of obstruction. A uterine interposition operation rarely obstructs in just this manner as in these cases the greatest bladder floor pressure is usually at or near the interureteric bar.

Caruncle alters bladder function by obstruction, reflex stimulation, or predisposing to urethritis. Per se, however, it is, as a rule, too far anterior to effect a change in function by reflex.

SURGERY OF THE NERVOUS SYSTEM FOR THE RELIEF OF BLADDER SYMPTOMS

The status of neurological bladder surgery is, while increasing in stability, still confronted with one basic barrier, namely, the lack of common consent and understanding as to bladder function, its nerves, and myogenic components. The points to consider in this regard are the acceptance or refusal of such "micturition centers" as Cortical, Hypothalmic, Bulbar, Sacral, Lumbar (Beattie)[6]; Barrington's[4] five reflexes; the function of the sympathetics (hypogastric nerve), of the parasympathetics (pelvic-nervi-erigentes), and whether their placement is entirely within or partially without the internal sphincter; mode of action of the external voluntary sphincter; extent and ability of the pelvic nerve to assume the function of the pudic nerve; and a constant application of secondary myogenic changes. In my opinion, a lack of appreciation of this last point accounts for a greater part of the doubt engendered by physiologic disputes. Further, with myogenic function in mind, I feel that we now have, in the physiology as set forth here, sufficient evidence for its clinical application.

The presacral nerve is either a loose plexus or a thick or flat nerve mass lying centrally below the bifurcation of the aorta. It is formed by fibers from the lumbar-sympathetic chain and, for purposes of discussion, I quote from and summarize Learmonth's[13] discussion before the Royal Society of Medicine of London in 1932.

1. Presence of inhibitory fibers: Learmonth has been unable to demonstrate definite dilatation of the bladder on faradic stimulation of its sympathetic nerves. He states that the most convincing evidence regarding the presence of inhibitory fibers has been clinical.

2. Presence of pain fibers: This was demonstrated at operation by the fact that when the presacral nerve was grasped with forceps a "crushing pain in the bladder" resulted.

3. Faradic stimulation of the presacral nerve produces strong contraction of the bladder.

4. Motor nerves to the muscle at the ureterovesical orifice: Stimulation of the presacral nerve causes contraction of both ureterovesical orifices to pinpoint size. As there is no special sphincter there, the effects may be attributed to the response of the trigone.

5. Motor fibers to the trigonal muscle: Stimulation of the presacral nerve causes contraction of the trigonal area of the bladder. After sympathetic neurectomy the trigone, at least in the male, becomes flaccid and atonic.

6. Behavior of the internal sphincter after sympathetic neurectomy: In patients with a normally innervated bladder the internal sphincter is at first dilated but in the course of two or three weeks recovers sufficient tone to close more or less completely.

7. Effects on micturition of division of the sympathetic nerves to the bladder: Frequency is not uncommon for a few days after operation but at the end of that time micturition is normal in every way.

In the case of females, division of the presacral nerve has been followed by normal pregnancy and labor. Occasionally it is immediately followed by menstruation. After the operation on males there is no difficulty in the performance of the sexual act and a psychical orgasm is experienced but ejaculation does not occur.

Presacral resection (Learmonth[32]) will, in properly chosen cases, reduce or abolish residual urine, increase intracystic pressure, and relieve some pain associated with bladder wall (increased intramural tension). In certain instances it is well chosen, the determination lying in the extent of the imbalance between sphincter resistance and expulsive force of the bladder wall. If the balance of power in favor of sphincter resistance is too great, bladder-wall decompensation will occur after the operation and a residual urine reappears or increases in amount. Further, in bladders with preoperative ureteral regurgitation the operation may be contraindicated in that the bladder function changes brought about by the operation would increase regurgitation and definitely slow ureteral emptying. This may, in previously dilated ureters, contribute to a laying down of mineral salts in the renal pelvis, increase renal back-pressure pain, or exacerbate a pyelonephritis. Pain conducted over pelvic or pudic nerve one would not expect to be relieved. The operation is well conceived, a definite step toward furthering our knowledge of bladder function and, in bladders carefully chosen, with the above exceptions, has given desirable results.

The pudic nerve offers possibilities of treatment by section or injection for pruritis vulvæ or ani, urethral spasm, pudic nerve neuritis, et cetera, after all reflex possibilities have been removed. The effects of its section on micturition, according to Learmonth, are transient, its function being evidently assumed by the pelvic nerve — an argument in favor of some pelvic nerve distribution to the posterior urethra.

Allergy undeniably may cause vasomotor changes, with resulting colicky pains of varying severity in either kidney. The peristalsis of the ureter may also be interfered with in like manner. Allergic bladder dysfunction is difficult to diagnose and rare in occurrence. It exhibits itself as a hyper-irritable bladder.

KIDNEY AND URETER

Functionally it is quite impossible to separate kidney and ureter on account of the close interdependence of the two. The effects of ureteral changes upon the kidney and those of kidney changes upon the ureter are well known. The recent excellent work of Lawrence R. Wharton[66] shows that ureteral innervation from the lowest renal ganglion down through the aortic, hypogastric, and pelvic plexuses do not have to do with ureteral peristalsis and that the ureter may be stripped of these nerves without causing a pelvic dilatation. Wharton believes that these nerves carry pain sensations alone. The lowest plexus (pelvic) physiologically interweaves ureter into bladder, seminal vesicle, rectum, and sacral cord.

The lower ureter, which can be palpated through the rectum or vagina, and its contact with the seminal vesicles, is a most important area. It can cause severe reflex kidney pains. We recall that the ureter has an inner longitudinal and outer circular coat of muscle. In the lower portion there is an additional external long coat. This reënforcement accounts in part for the painful spasm of this portion of the ureter in that it is more powerful.

Andler[1] feels that motor fibers reach the ureter via the pedicle and that it is necessary to denervate the renal artery and vein to cause ureteral or pelvic hydronephrosis or atony.

The kidney is sensitive to direct pressure (squeezing it slightly by hand), enlargement within its capsule, or compression within its capsule (seen in sclerotic kidneys), traction on the renal pedicle, or by distention of its pelvis. An intrarenal pelvis[50] has less elasticity and is therefore painful earlier in distention than an extrarenal pelvis. Both pelvis and ureter, as well as pedicle, are sensitive to pressure from without. The pelvis is sensitive to sensations of heat and cold. Pain of pelvic or ureteral stone is due chiefly to secondary urinary distention, the localized muscle spasm, and direct trauma to the mucosa. Pelvic pain is often accompanied by nausea, vomiting, pallor, and cold sweats. The pulse and respiration reflexes are not directly influenced. Renal pain is usually a renal pelvic pain due to its distention and is usually spoken of as "colic," the one exception being torsion of the pedicle (Papin and Ambard[40]).

The existence of secretory nerves is in doubt but it is known that denervation of the kidney and its pedicle does not stop renal secretion nor, according to McCaughan[34], does it increase the secretion pressure of the urine. Howell[27] states that: "The majority of purely physiological experiments upon direct stimulation of the nerves going to the kidneys are adverse to the theory of secretory fibers, the marked effects obtained on these experiments being all explicable by the changes produced in the blood flow through the kidneys." Neither Cushny[14] nor A. N. Richards[43] in their work on the theory of urinary secretion makes use of the existence of secretory nerves.

The kidney is innervated by way of the renal plexus which, in turn, communicates with the vagus and greater and lesser splanchnics. Spinal segments from the sixth dorsal to the fourth lumbar are interested in this supply. The renal plexus consisting of ganglia and fibers is arranged in a network about the contents of the hilum of the kidney, the vessels, pelvis, and upper ureter. Further, some sympathetic fibers reach the kidney along the fatty capsule blood vessels, aberrant or polar vessels, and the constant artery found between the kidney and adrenals.

Vesico-renal reflex. Sacco[54], studying the functional relationship between the urinary bladder and the kidneys in dogs, found that mild stimulation of the bladder, that is, distention up to a pressure of twenty-seven millimeters of water, caused an increase in the size of the kidney and in the output of urine, while greater stimulation caused a decrease in the size of the kidney and in the output of urine. If, now, the inferior mesenteric ganglion were removed and the stimuli reapplied, these changes would be slower and inconstant. In fact, stimulation of the inferior mesenteric ganglion would produce the same results. In all instances the ureter was cut before stimulation was applied and only minor changes in the blood pressure were noted. As the amount of intracystic pressure necessary to elicit the vesico-renal reflex was only slightly above *normal voiding pressure* he *concludes that pain is probably not a factor.*

The results of Farrell[20] secure very definite decreased renal activity with vesical distention and with very little blood-pressure change, but, with both splanchnic nerves cut, neither bladder stimulation nor stimulation of the pelvic nerve influenced urinary secretion.

Reno-renal reflex. This reflex is well established clinically. Burton and Opitz[10] show that innervation of the kidney is unilateral. J. I. Farrell[20] shows that by suddenly distending one pelvis there is a marked decrease in the urinary output of the opposite side. Farrell also found that distention of the bladder caused an inhibition of urinary output followed by rapid diuresis when the distention was released. (Such an explanation is often applicable in the analysis of symptoms.) He further found that stimulation of the pelvic nerve on the right side caused complete cessation of urinary flow as long as stimulation continued but no compensatory diuresis followed. Stimulation of the hypogastric nerve had no effect. Voiding caused cessation of ureteral peristalsis during active bladder contraction.

According to E. Hess[26] the indications for renal sympathectomy are as follows in the order of their importance:

1. Nephralgia, with or without accompanying non-obstructive hydronephrosis.

2. Unilateral hematuria, classified heretofore as "essential bleeding," without any clinical evidence of renal pathology.

3. As an adjunct to the removal of stones in the pelvis of the kidney or the ureter with the idea of protection subsequently.

4. Anuria that lasts longer than a few hours.

5. It is suggested as an operation to be used in both bilateral and, most particularly, in unilateral early tuberculosis.

The operation was first done by Papin and Ambard[40]. In discussing their work and that of Legueu and Flandrin[33], Eisendrath[18] states that it is important to note that decapsulation and nephropexy were also performed. The operations were done for the relief of pain in chronic nephritis, small degrees of hydronephrosis, and pure nephralgias.

Milliken and Karr[37] conclude that most of the cases operated on for painful nephrosis and nephralgia obtain complete relief of pain in a few days after operation which, they believe, is sufficient proof of the practicability of tearing out the nerves in the pedicle of the kidney.

Theoretically they believe it to be the logical procedure in reflex anuria and oliguria. They recognize that reflex anuria and oliguria are produced by spasm of the renal vessels occasioned by reflex stimulation of the vaso-constrictors, which impulses are carried only by the splanchnics, and that anesthetization of these splanchnic nerves or their destruction will prevent continuation of the anuria and oliguria. They therefore feel that this method will be preferable to decapsulation of the kidney in such conditions.

They further theorize that denervation of the kidney, or sympathectomy, increases the blood supply of the kidney and, in chosen cases, that it might be possible to arrest a tuberculous infection of the kidney by this method through the beneficial action of the increased vascularity. In support of this theory they mention the cases reported by Lowen[37a] in which tuberculosis of the extremities has been arrested by periarterial sympathectomy, and feel that it would be more apt to secure a satisfactory result in a vascular organ such as the kidney than would be expected in a joint. As to the value of sympathectomy for the prevention of the reformation of renal calculi, they theorize that a better flushing of the kidney by a more diluted urine would be less likely to cause a stone than with a urine of heavier specific gravity, it being definitely proven that a denervated kidney shows an increase in the amount of urine which is of lower specific gravity.

Theoretically, they prefer the operation to decapsulation of the kidney in that it would be less mutilating and would give as good or better result in certain forms of nephritis.

They call attention to Boeminghaus[8], who is of the opinion that the effect of decapsulation is quite similar to denervation, and quote him: "Theoretically decapsulation is not well founded since the expected permanent relief of pressure or improved vascularization is not obtained." In this connection Milliken and Karr feel that cicatrization secondary to decapsulation would vitiate the good result of the operation.

In the light of work recently completed[50], we feel that, in all these conclusions and theories, the great difference of opinion lies chiefly in the fact that normal kidney pelves vary in shape, size, placement, and function to such an extent as to allow analysis from the viewpoint of stone formation, nephralgia, idiopathic hematuria, or any other pathology an individual problem in each instance. In a large class of kidneys presenting any of these pathological problems, it is our opinion that denervation is, if not curative, at least a step in the right direction surgically. That is, it is often curative in the nephralgias and idiopathic hematurias, but doubt remains as to its value in stone formation and in both simple and tuberculous infections.

E. Hess[26] concludes: "The operation of renal sympathectomy is feasible, easy and practical. By its use many kidneys which otherwise would be sacrificed can now be saved. It is logical to believe that unilateral unexplained renal hemorrhage, renalgia, anuria and certain types of nephritis may be successfully handled by employment of this procedure."

The operation. Milliken and Karr[37] favor the median abdominal or longitudinal rectus incision, Hess[26] the usual kidney flank manner. The latter is the operation of choice today and his description of his technic is: "The kidney is exposed by way of the usual flank incisions. The perirenal fat is next separated and the kidney delivered into the wound. The ureter is next found and completely freed as far down into the pelvis as possible. No attempt is made to conserve the blood supply, nerve supply or the lymphatics in this freeing. The little vessels running into the parenchyma of the kidney through the capsule are sacrificed in the delivery. Retractors are now placed in the wound so that the exposure of the pedicle is facilitated and with gauze the pedicle is gently stripped of all of its fatty sheath, care being taken not to injure the thin-walled veins. This fatty sheath containing lymphatics and nerves is stripped as far down toward the aorta and vena cava as possible. The fibrous sheath surrounding the arteries and veins is gently teased away with forceps and stripped back away from the kidney. Any small nerve filaments or lymphatics are picked up on a grooved director and cut until the vessels of the pedicle are left completely exposed on all sides from any fascial covering for a distance of at least one-half inch and preferably further."

"As there are undoubtedly some nerve fibers running into the kidney in the wall of the arteries, no attempt is made to destroy these, as from a clinical standpoint this is not found to be necessary. The kidney is then replaced in its bed and the wound closed according to the technique of the operator."

It is possible to tear the renal vein in cleaning off the pedicle, and kidneys have been sacrificed for this reason.

Harris and Harris[24], in their use of pyeloscopic and pyelographic indications, conclude that there are three groups suitable for renal sympathectomy:

"Group a: Irregular and incomplete contractions of the calyces and renal pelvis so that the impulse for peristalsis either does not reach or does not pass beyond the ureteropelvic junction. Delayed emptying time is a natural corollary."

"This group is characterized by intermittent colicky pain, generally, though not necessarily, of a moderate grade of severity."

"Group b: Marked slowing down with irregularity and increased power of contractions, associated generally with dilatation of the renal pelvis and clubbing of the calyces. Delayed emptying time is a factor here also." "Clinically this group is characterized by more persistent, dull pain with liability to acute exacerbations."

"Group c: Dilatation and immobility of a single calyx and its delayed emptying." This group, they feel, is a variant of Group b.

Their operative technic is through a boomerang-shaped lumbar incision to completely deliver the kidney from fascial and fatty covering. They then deliver the kidney, starting gauze dissection as far away from the kidney as reasonably possible and working continuously outward toward the kidney. Dissecting with gauze from the kidney hilus outward toward the aorta and vena cava they believe to be dangerous from the standpoint of tearing small branches of the renal artery and vein.

They believe: "That the following findings constitute a syndrome definitely indicative of Renal Sympathetico-Tonus:—

1. Positive pain reproduction test on cystoscopic examination.
2. Positive pyeloscopic and pyelographic findings as described in groups a, b, and c.
3. Delayed emptying time of the renal pelvis and calyces, or possibly of a single calyx.
4. Recurrence of pain after its temporary relief by Eserin.
5. Evidence of generalized Sympathetico-Tonus, which may be most marked on the side of the lesion.
6. Negative urinary findings on microscopic and cultural examinations.
7. Proved absence of organic ureteral stricture."

They conclude: "The operation of renal sympathectomy may be undertaken in the presence of the above-mentioned findings, with the confident anticipation of complete and permanent relief of pain. Whether the operation will find a place in the treatment of so-called essential hematuria and of some types of nephritis remains yet to be proved."

It is evident that renal sympathectomy is a valuable adjunct; that it does not produce hydronephrosis or interfere in a derogatory manner with kidney function; that some of the innervation will regenerate, in part at least, in a year or two, but that the symptoms for which the operation was performed do not return.

Decapsulation with renal sympathectomy is unusual but nephropexy, in cases of second and third degree ptosis should be performed at the same time. Aberrant blood vessels should also be searched for and managed according to their importance. Closely associated with this operation, from a clinical standpoint, is that of ureteral denervation and freeing and displacing of the ureter.

Ureteral denervation. The indications are ureteralgia or ureteral spasm uncomplicated by other urological findings and not obviously secondary to adjacent pathology. Wharton[66, 67] concludes that: "The ureter receives a nerve supply which is independent of the innervation of the kidney and bladder." "These nerves go directly to the ureter from (1) the lowest renal ganglion of the upper end of the spermatic plexus; (2) the abdominal sympathetics, the aortic, hypogastric, and pelvic plexuses."

"We have also confirmed the observations that the abdominal sympathetic plexus (aortic) receives branches from the upper lumbar sympathetic ganglia (prevertebral), and that the pelvic plexus has direct connections with the sacral cord."

"Our dissections show that there is a connection between the ureteral innervation on the one hand, and the plexuses that supply the ovary, testis, and parietal peritoneum. This phase of the subject requires further investigation."

"These ureteral nerves can be easily isolated during the course of surgical operations, excised, and identified histologically."

"These anatomical conclusions have been based on dissections in human beings. No structure has been identified as nerve except by microscopic examination of a permanent preparation that has been stained satisfactorily."

"From the physiologic viewpoint, our clinical observations would lead us to conclude that cutting these ureteral nerves as we do in ureteral denervation, does not interfere with the motor function of the ureter and does not cause atony, hydroureter, stricture, or any ureteral disturbance. These observations have since been confirmed by Andler[1] Trattner, Wright and Barlow[61] and Frommolt[21] in animals."

"On the basis of clinical observations, also, we are of the opinion that one of the functions of these ureteral nerves is the transmission of painful sensations. Since this suggestion is based on clinical observations only, it should not be accepted as an established fact until further evidence has been adduced."

"Similarly, the clinical application of the above-mentioned anatomical and physiological data should be conservative."

"We have briefly outlined the present status of our knowledge concerning the innervation of the genito-urinary organs; we know of no greater opportunity for careful, precise research at the present time than this phase of urology and gynecology."

The following is an interesting point brought out in Wharton's article: "Maier[36] therefore concluded that the urinary organs have the same characteristics that Remak, Meissner, Auerbach, and others had found in the intestinal tract and the heart — namely, the ureter, bladder, and urethra possess intrinsic neuro-muscular mechanisms by which they function automatically and initiate their own muscular contractions, without the necessity of external neural connections. In his opinion this intrinsic urinary neural mechanism has connection with the central nervous system and reacts to stimuli from that apparatus and also other regulatory mechanisms."

The operation. Denervation of the ureter, as described by Wharton and Hughson[67] and performed in two instances, one on a remaining kidney after removal of the opposite one for tuberculosis, was through "a long mid-line, suprapubic incision." After examining the abdominal and pelvic organs, "the posterior layer over the ureter was opened exposing it from the bladder to the fourth lumbar vertebra. The lowest or terminal ureter between the broad ligament alone was not detached and cleaned of every attachment."

The results were excellent, no hydronephrosis resulted, as shown by a pyelogram in one case five months later, and it was noted that the ureter, after denervation, was much less sensitive to catheterization than before operation.

This study of the ureteral innervation offers explanation of many obscure symptoms and, in studies sufficiently complete to rule out all other possible causes of uretero-nephralgia, it can be undertaken.

If the spastic ureter is in the lower portion, some simple gynecological procedure, or emptying a seminal vesicle by massage, correcting bony deformity (secondary to an old poliomyelitis, for example) or a simple faulty posture may correct the ureteralgia. In other instances such a low ureteral stasis may be augmented by a small ureteral orifice. Instances will be found in which passage of an ureteral bougie-à-boule will give a hang at a point strongly suggestive of ureteral stricture, the only difficulty being that the "hang" is not present at every examination. In such instances we decide that we are dealing with ureteral spasm. After ruling out ureteral stricture and other possibilities equally doubtful, we are offered a possibility for relief by performing ureteral denervation.

Ureteral reflux. Regurgitation of bladder contents to the kidney pelvis is extremely important in infections, from the standpoint that the bladder furnishes heat, warmth, moisture, food and time for the multiplication of organisms which may be regurgitated continuously to reinfect the kidney pelvis. Reflux, in a majority of cases, probably occurs only during the onset and finish of the act of urination. In some instances, however, the pelvis is in constant communication through patent ureteral orifices.

Bumpus[9] finds renal reflux associated, in high incidence, with many tuberculous and pyogenic cases of cystitis; Eisendrath[18] with bladder-neck obstructions; Graves and Davidoff[22] with increased muscular tone. Cystometric conclusions agree with all three, that is, as due to sudden, forceful contraction of the bladder with consequent thickening and irritability, and they suggest that the reflux takes place with the onset or termination of bladder-wall contraction depending on the bladder capacity. In those of small capacity and strong contractions it often occurs at the onset. In the thinned bladder wall with a large residual urine it occurs toward the end of the emptying. However, the bladder wall is only the inciting factor of reflux. We must consider the ureteral orifice, its type of valve[23] and its placement. Again, there is a difference in opinion as to the importance of the ureteral valve because with it some other factors are associated of which the chief one is bladder wall change. Kreutzmann[30] feels that this bladder-wall hypertrophy causes compression of the ureter in some cases, while Tandler and Zuckerkandl[59] think that the vas deferens looping over the ureter causes back-pressure but not necessarily reflux, although there is a feeling extant that a back-pressure ureter tends to permit reflux by reducing the ureteral resistance.

Barksdale and Baker[2] show, in dogs, that interfering with the nerve supply of the lower ureter does not exert any effect on ureteral reflux. The work of Wharton[66], showing the pelvic plexus and its ramifications about the lower ureters, base of the bladder, pelvic organs, and connection with the sacral cord, offers an explanation for the cause of transient lower ureteral block, either constant or inconstant, which would interfere with renal function without reflux.

In children reflux is more frequent than in adults and offers partial explanation of pyelonephritis in childhood, sometimes clearing up as the bladder undergoes the change of position occurring with age up to twenty years as outlined elsewhere, and at other times continuing the low-grade infection throughout life.

In each instance of renal change reflux is one of the possible factors in the individual analysis of the specific case. All are agreed that it is most likely to occur in a bladder wall of an unusually strong musculature but by no means in each instance. Given a type of ureteral orifice which will permit of reflux, a compensated bladder wall, and yet with a sphincter resistance equal to or slightly in excess of the expulsive force, and we have the proper setting for ureteral reflux.

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SURGERY OF THE BLADDER

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SURGERY OF THE BLADDER

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EMBRYOLOGY OF THE BLADDER

The bladder is formed from part of the terminal portion of the primitive gut. The first dilatation is the cloaca and into this open the Wolffian and allantoic ducts. Along its ventral surface where the cloaca comes in contact with the ectoderm of the body wall, there is formed the cloacal membrane, which extends from the umbilicus to the base of the coccyx.

Now the rectum is separated from the bladder by the growth of a septum which begins in the ridge between the allantois and the hind-gut. and passes caudally until it meets and fuses with the cloacal membrane. In this way are formed the urogenital and anal membranes, these later being perforated to form the urogenital and anal openings.

Originally, the Wolffian ducts open into the dorso-lateral walls of the cloaca and with its divisions into rectal and urogenital portions, their ends remain on the urogenital side. With the growth of the bladder wall the terminal portions of the Wolffian duct become splayed out on its surface, thus drawing the ureteral orifices down onto the bladder wall. Also, as the greater growth of the bladder is in its upper portion, the ureteral orifices are carried upwards and outwards, while the ends of the Wolffian ducts remain closely together and at a much lower level. As the Wolffian ducts are mesoderm, this gives to the bladder a triangular portion, corresponding to the trigone, which is mesodermal in origin, whereas the remainder formed from the original hind-gut, is endoderm. The muscular coat of the bladder wall comes from a condensation of the surrounding mesenchyma.

As mentioned above, the upper or vesical portion of the original bladder grows more rapidly, while the lower or urethral portion grows more slowly and remains as a narrow channel, forming the whole length of the female urethra, and in the male that part of the urethra between the bladder and the verumontanum.

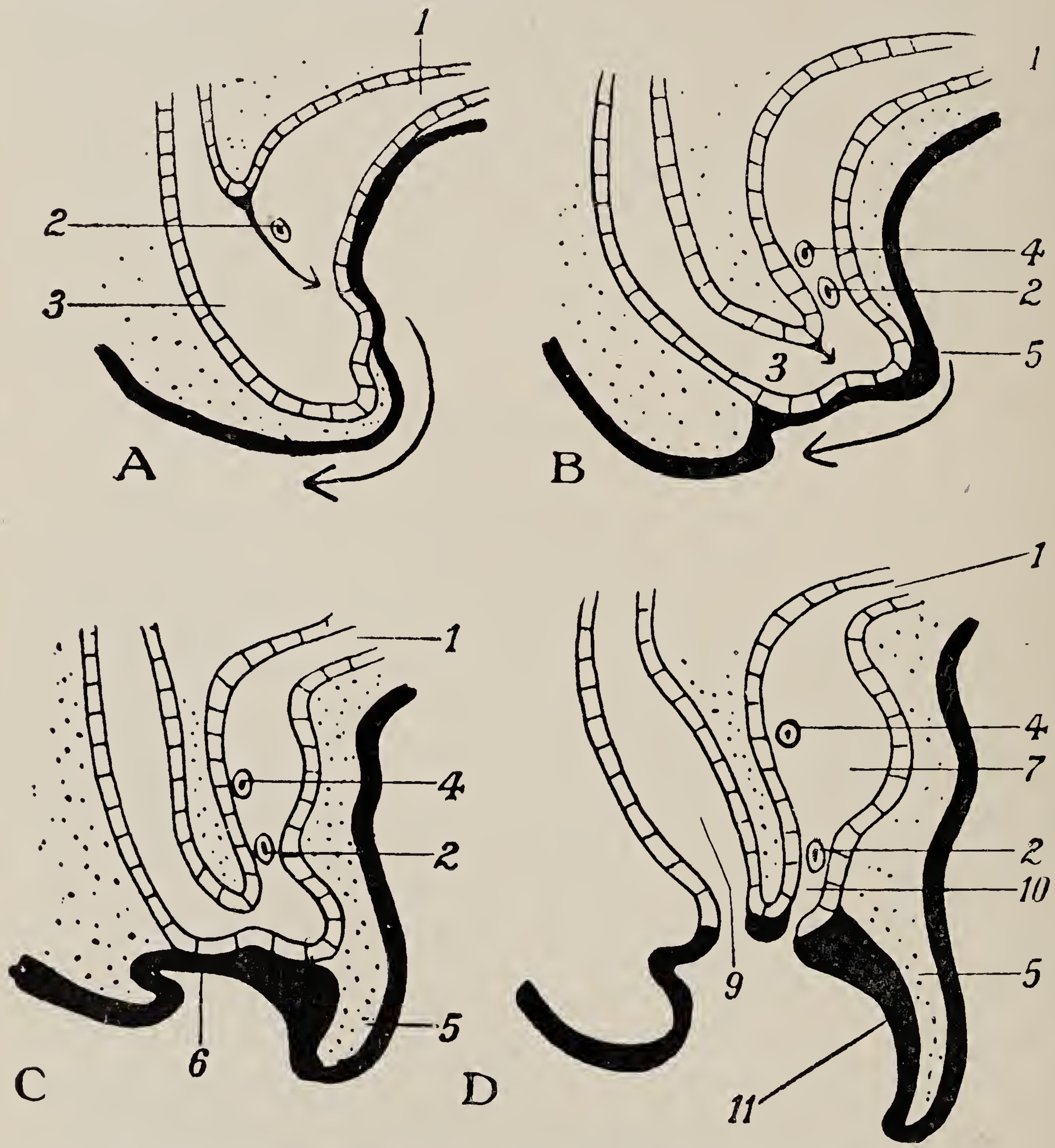

FIG. 1. Four diagrams after Hunter, showing changes in the hind end of the primitive gut, which result in the formation of the rectum and bladder.

1. Allantois
2. Opening of Wolffian duct.
3. Cloaca
4. Ureteral opening
5. Genital tubercle
6. Cloacal membrane
7. Bladder
8. Urogenital sinus
9. Rectum

The allantoic duct later loses its importance — the lumen becomes occluded and the duct forms an impervious cord now known as the urachus.

THE ANOMALIES OF THE BLADDER

Anomalies of the bladder are comparatively rare, the most important one of these being exstrophy.

EXSTROPHY

Exstrophy of the bladder is a condition in which there is an absence of the anterior wall of the bladder and of the overlying abdominal wall. In appearance there is a reddened protrusion or herniation of the posterior wall and floor of the bladder through the abdominal wall. The ureteral orifices and trigone are readily visible.

In the male, in which it is more common, there is usually an accompanying epispadias. Cryptorchidism, hernia and other anomalies are frequently associated with this condition. In the female there is a wide separation of the labia minora anteriorly and the clitoris is divided so that the vaginal opening is exposed. In both sexes there is usually absence of the symphysis pubis with wide separation of the pubic bones and recti muscles. Eisendrath describes an incomplete type in which there is only a defect of the upper or lower portion of the bladder wall. The symphysis is united and there is no accompanying epispadias.

Etiology. The generally accepted view is that there is an upward continuation of the cloacal membrane, so that the mesoderm fails to develop the abdominal wall between the genital tubercle and the umbilicus.

Clinically, the patient is most uncomfortable. There is constant wetting, with excoriation of the surrounding skin, and friction on the mucosal surface causes bleeding. There is in time a gradual dilatation of the renal pelvis, with or without infection. The ureters are almost always markedly dilated.

Carcinoma of the bladder in these cases due to the constant friction, has been reported, and Deming collected ten cases in 1927, all of them in males.

Treatment. The treatment of exstrophy of the bladder is either palliative or radical.

Palliative treatment requires constant care and cleanliness and the prevention of ulceration of the mucosa of the bladder as well as that of the surrounding skin surface.

Radical treatment has gone through successive stages up to the present time. The early attempts were usually unsatisfactory and the present success may be dated from the transplantation of the ureters into the bowel by the modern aseptic methods. Three main types of operations have been employed in the past.

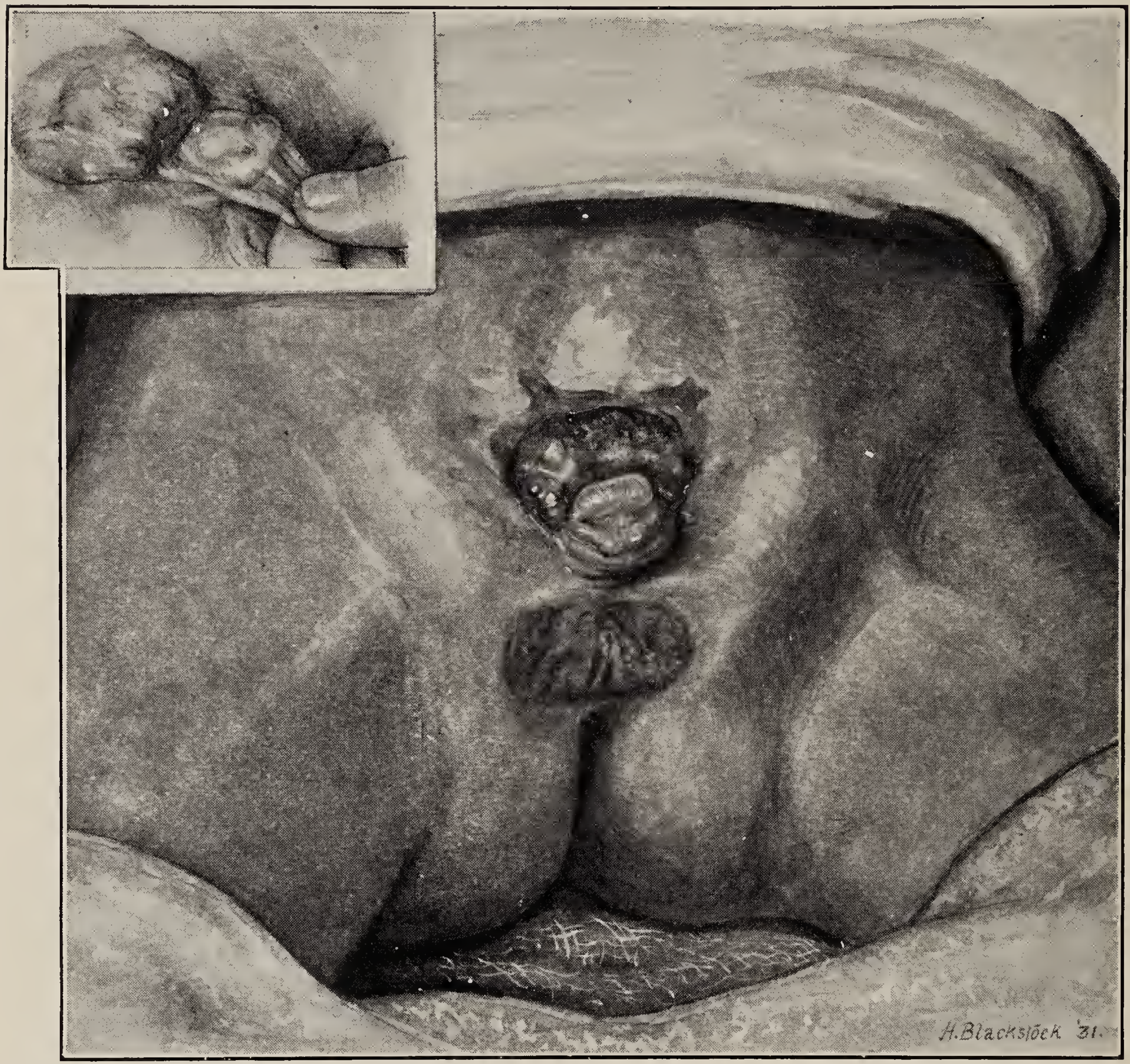

Fig. 2. Exstrophy of the bladder in a boy of ten years, showing protrusion of the bladder floor and wide separation of the recti muscles. There is an associated bilateral cryptorchidism and bilateral inguinal herniae. There is a complete epispadias — as shown in the insert (Author's case).

1. Plastics. These are impossible in view of the absence of a vesical sphincter.
2. Maydl's operation or transplantation of the trigone into the rectum.

3. Transplantation of the ureters into the bowel by the Coffey method.

This latter operation is the only one in use at the present time — either by transplantation of the right and left ureters into the cæcum and sigmoid respectively (Mayo), or by the original Coffey method, which he describes in his recent article as follows:

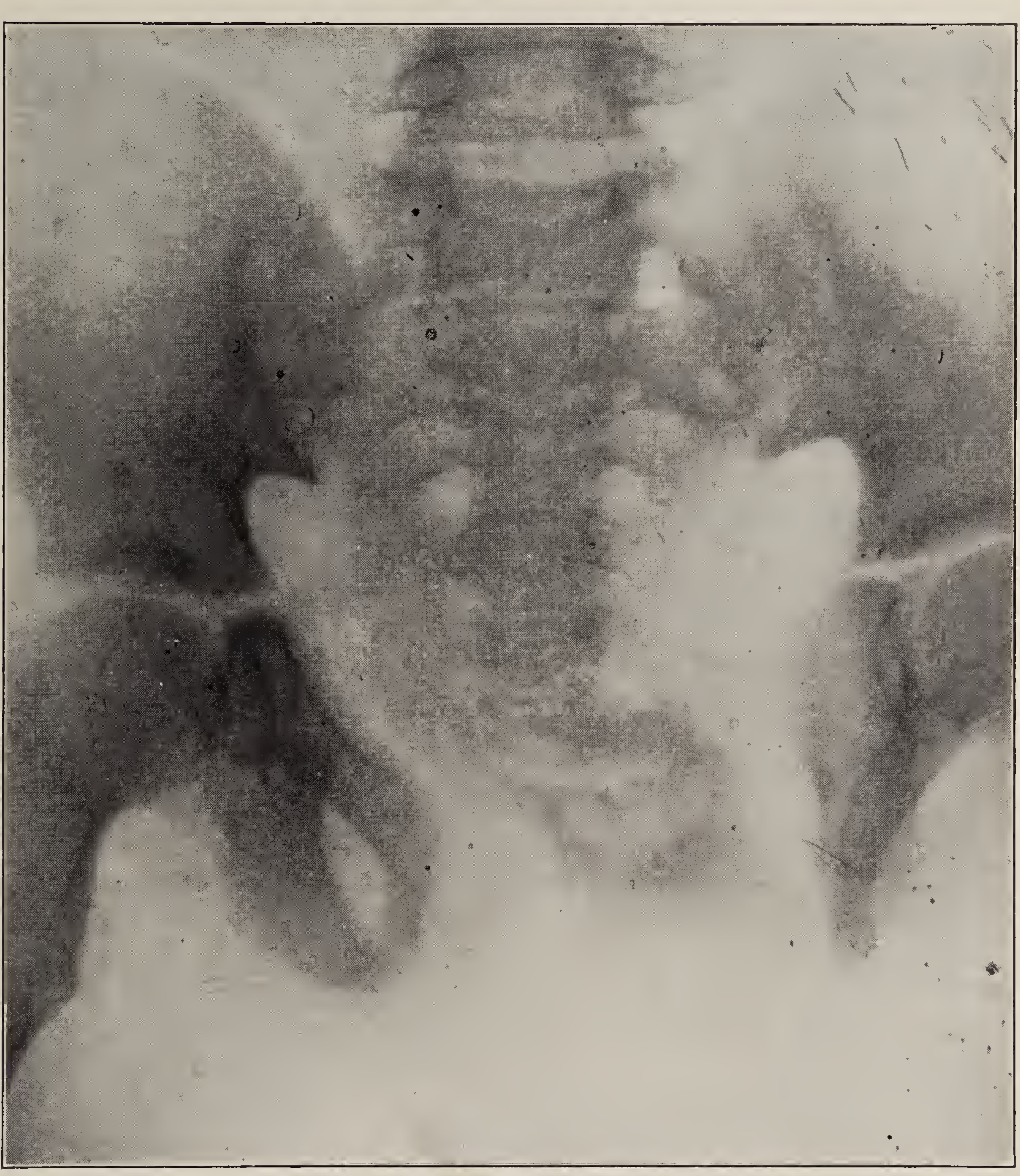

Fig. 3. X-ray of pubic bones of case in Fig. 2, showing lack of development of rami of pubic bones and absence of symphysis (Author's case).

"Assuming that the operation is to be done on Saturday, an ounce of castor oil is given on Thursday and again on Friday morning. On Friday evening and again early Saturday morning, the bowel is flushed with a high enema of clear water. A light diet is given on Friday and the patient is induced to drink all the water possible. At 7:00 A.M. Saturday, $\frac{1}{4}$ grain of morphine and $\frac{1}{150}$ grain of atropine are administered and a rectal tube is placed in the rectum to carry off any fluid which may come down. A general anæsthetic is started at 8:00 A.M. An incision extending from just above the umbilicus to the pubic bone is made just to the left of the middle of the abdomen. All the intestines except the sigmoid are carefully packed back and held above the promontory of the sacrum with a 5-yard pack of gauze. A thin-bladed, curved, rubber-covered stomach clamp is now placed on the sigmoid 12 to 14 inches above the anus, thus isolating this lower segment.

"The patient is now drawn down to the end of the table so that the buttocks protrude beyond the table. A skilled assistant inserts a sigmoidoscope, 30 centimeters long, into the rectum and on into the sigmoid, guided by the operator's left hand manipulating within the abdomen. A tube 2 feet long in which has been fastened a beveled edged needle (No. 13 Lewishon transfusion needle) is coupled to the tube of an irrigator which is arranged at considerable height. The needle is thrust through the wall of the sigmoid just below the clamp and the water is turned on. The sigmoidoscope is drawn down so that the end is within an inch or two of the anus. The water, when it begins to flow through the sigmoidoscope, usually contains small particles of fæcal matter and mucus. As soon as this is entirely clear, 500 cubic centimeters of a 1 per cent solution of mercurochrome is put in the irrigator (as suggested by Dr. L. L. McArthur, of Chicago, in a personal communication). After the irrigation is finished and the fluid has entirely drained away through the sigmoidoscope, the obturator is again inserted and the sigmoidoscope under the guidance of the operator's hand within the abdomen is pushed upward to within an inch of the obstructing clamp. Sterilized gauze packing, folded from a strip of gauze 4 inches wide and extending to a length of about 10 feet, is now used to pack the lower bowel. For this purpose, a laryngeal forceps with a straight shaft of somewhat more than 30 centimeters is used. As the assistant from below introduces the gauze with forceps, the placing of the gauze is guided by the operator's left hand within the abdomen. As the bowel is filled with gauze, the sigmoidoscope is gradually withdrawn. The assistant is carefully instructed to include a considerable mass of gauze in his forceps so as to prevent the end of the forceps from injuring or penetrating the intestinal wall. After the segment of bowel from the clamp downward has been filled with sterile gauze, the patient is drawn back on the table and placed in a moderate Trendelenburg position.

"The posterior parietal peritoneum is now incised over the most convenient approach to one ureter. Through this incision, the ureter is located and picked up on a smooth retractor. The incision is extended both ways as much as needed to expose the field. The finger, curved under the ureter, is slipped down like a hook toward the bladder, freeing the ureter of its connective tissue and pushing down the structures of the broad ligament in a woman, to a point as near its entrance in the bladder as possible. Under the guidance of the left index finger used as a hook, a small Kocher clamp is placed on the ureter. Another is placed just proximal to it. The ureter is now severed with a knife. The distal stub of ureter is tied with catgut just below the forceps. If no drainage is to be used, the stump should be cauterized with carbolic acid. The other ureter is lifted in like manner and the two clamped ureters are drawn through the upper end of the wound. If drainage is to be used (and my personal opinion is that it is safer, particularly for one doing his first operation of this kind), gauze is packed into and over these slits in the peritoneum while the further steps of the operation proceed.

"Two No. 12, whistle tip, ureteral catheters have been sterilized and prepared by fastening a cuff of rubber tubing on the catheter about 6 or 7 inches from its tip. At the other end of the catheter is fastened a double linen thread armed with a round needle to be used in fastening the end of the catheter to the gauze within the rectum. The end of one of the catheters has been sloped for identification. The clamp holding the ureter is taken in the left hand while a knife in the right hand splits the anterior wall of the ureter. A catheter is now inserted into the first ureter down to the rubber cuff. Two strong double linen ligatures are now tied around the slit portion of the ureter and around the anchor cuff. A third strong linen suture is placed around the ureter above the cuff for the double purpose of completely shutting the intestinal contents off from the ureteral canal and of furnishing strangulation of the ureter at this point so as to form a line of separation later.

"Attention is next turned to the intestinal part of the operation. The lowest point in the sigmoid at which the operation can be conveniently done is to be considered the site of election. Using two incisions, I have found it more convenient to transplant the left ureter in the lower incision. The lower end of the upper or right incision should be at a higher level on the intestine than the upper end of the lower or left incision. The incisions are made diagonally about an inch and a half in length, extending from the mesentery's edge downward and toward the midline of the intestine. While on dogs I have successfully and easily performed the operation in which the incisions were made on the same level and the ureters brought out through a single opening and while Charles Morgan McKenna, of Chicago, experimentally, and Herbert Coe, of Seattle, clinically, have transplanted both ureters through a single longitudinal incision with separate stab wounds in the mucosa for each of the two ureters, I think two separate incisions at different levels is possibly the best plan. Using this plan, two traction loops of No. o catgut in which both ends are left long are placed at each end of the proposed incision about one-half inch apart, and including the muscular coat of the bowel, also including any nearby vessels which cross the incision and which might bleed during the operation.

"With traction loops made taut, the surgeon with a fine bladed knife carefully makes each incision through the peritoneal and muscular coats. With the handle of the knife, the muscular coat is pushed off the mucosa. The ureter is now placed between the two upper traction loops of each excision. With a fine sharp-pointed knife, a small stab wound is made through the mucosa at the lower angle of the incision. A very fine Halstead mosquito forceps is thrust through this tiny opening where it seizes a bite of gauze within the intestine and pulls a small bit of the gauze through this puncture. To the gauze in these two wounds, the two catheters are sewed. It is important at this juncture to determine and record which ureter contains the catheter with the sloping edge.

"At this point, the nurse begins to withdraw the gauze from the anus. As the gauze begins to tug on the lower catheter, the surgeon carefully guides the end into the bowel. The gauze is pulled down until the end of the lower catheter comes through the anus. Then the pull is made on the catheter. When the end of the ureter around the cuff approaches the wound it is sometimes necessary to dilate the opening in the mucosa slightly so as to permit the ureter to enter the bowel. After it is pulled down comfortably taut, the nurse again pulls on the gauze until the end of the other catheter approaches the opening. This catheter is pulled down in the same way as the first one. At this point it is just as well to remove the remainder of the gauze because it may be inadvertently picked up by a suture and may make trouble in pulling it out later.

"With the ureters lying comfortably in their relative incisions, the two traction sutures at the lower angle of the lower incision are made taut. A fine curved needle threaded with No. ooo chromic catgut, double thread, is passed through the peritoneum and musculature of one side of the incision, and picks up a good bite of the ureteral wall, then the other side of the intestinal wall, thus fixing the ureter in the lower end of the wound.

It is probably well to use two sutures which take a bite of the ureter. The sutures are usually tied as they are placed rather than all left loose as shown in the illustrations. The other sutures pick up the intestinal wall just outside of the incision and roll the edges in over the ureter. These may be of No. 0 catgut. The traction loops may now be cut or tied together and another line of sutures, either continuous or interrupted, may be used to cover in the first line. The ureters, after the operation is complete, should be covered in by peritoneum and not left exposed to the intestines.

"If drainage is to be used, a continuous suture begins to bring the edges of the peritoneal incision together just above the ureter. After the second or third stitch, the inner edge of the peritoneum is dropped and the outer edge is drawn over to the side of the intestine where it is sutured and from which point the continuous suture follows the intestine downward, partially covering the line of suture. As it approaches the lower end, it turns outward toward the inner cut edge. This leaves a retroperitoneal space through which any infection that may emanate from the line of sutures, may travel downward to a drain. The lower part of the incision is left open. The four ends of two double wicks are placed in the lower angle of each peritoneal incision. Two more double wicks are placed in the cul-de-sac. Two folded sheets of gutta percha tissue cover in the gauze so that no intestine can touch it and the wound is closed, leaving this quarantine pack coming from the lower end of the incision. One week after the operation, the gauze wicks are carefully and separately withdrawn; 4 to 7 days later the gutta percha is removed and the wound is allowed to heal of its own accord.

"The method of construction of this quarantine drainage is described in Annals of Surgery, June, 1927. Some, of course, may prefer simple rubber tissue drains, some tube drains. Because of the danger of intestinal obstruction around such a drain, however, I think it is better to use no drainage at all than to use anything except the quarantine which I have described. This method of quarantine drainage makes the operation very safe. Undoubtedly many operators will prefer to do the operation without drainage. If the abdomen is to be opened later for such operation as removal of the bladder, it would be more convenient to have no drainage at the transplantation operation.

"At the end of the operation, a fold of parietal peritoneum is drawn over the ureter to the intestine.

"There will be times when proper tubes may not be available or when, for other reasons, it will be necessary to transplant the ureter without a tube. In such cases, the same method of cleansing the bowel which has been described for the tube technique will be equally applicable. The dangers and difficulties which were experienced in the past in connection with unilateral transplantation without the tubes will be greatly abated. The same technique as has been described for the transplantation by the tube technique will be applicable except that the end of the ureter must be fixed by a suture to the inner side of the intestine, distal to the wound of entrance. In order to avoid the embarrassment of picking up the gauze within the intestine on the needle carrying the anchor suture, a grooved director is passed through the stab wound and its point made to lift up the wall of the bowel. A curved needle carrying the anchor suture is then passed along the grooved director where its point punctures the intestine. The needle is then drawn through and by pulling on the thread, one can drain the end of the ureter inside the intestine. By picking up a bite of the intestine near the place where the anchor suture has come through, one may tie a knot so as to anchor the split end of the ureter in place. The sutures are then placed by the same technique that has been described for the tube technique."

In our clinic we have for some years adhered to the method of first transplanting the right ureter into the cæcum, and at a later date, the left ureter into the sigmoid. As there is always a reaction in the kidney of the transplanted side, on account of infection and edema, this leaves the patient with a good kidney on the opposite side during this time.

We have transplanted the ureters in this way, in some six cases of exstrophy of the bladder, all of whom are living at the present time. One of our cases, a young woman of 26 years, transplanted 11 years ago, returned several years later for a Wolff graft to cover in the mucous surface. This was done after removing the mucous surface from the bladder floor.

Women seem more tolerant of the presence of urine in the bowel than do men, and the young woman mentioned above can sleep the whole night through without any trouble.

We do not advise this operation on very young children, on account of the lack of habit control, although one of our cases operated on successfully was a boy 2 years of age.

The prognosis in our group of cases has been good, and the mental effect on the patient of being continent, after such a distressing life, must not be overlooked.

Persistent urachus, or urachal fistulæ are sometimes seen. They may be open only at the bladder or at the umbilicus or both. In the latter case there is an escape of urine from the umbilicus.

Urachal cysts are not uncommon. There is no loss of patency in the lumen of the urachus, but the ends both at the bladder and the umbilicus are closed. Infection and abscess formation frequently occur in these cases. Absence of the bladder and double bladder have been reported, although extremely rare.

Persistence of the cloaca and perforations between the rectum and bladder due to their incomplete separation may also occur.

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DIVERTICULA OF THE BLADDER

A diverticulum is a protrusion or herniation of a part or the whole of the wall of the bladder, forming a cavity which communicates with the lumen of the bladder.

The types of diverticula are described as false, and true.

The false are cellules or shallow wide-mouthed depressions due to protrusion outwards of the epithelial lining between hypertrophied muscle bundles. They are multiple and are acquired, following vesical neck or urethral obstruction.

True diverticula on the other hand are more commonly single and much larger in size. When multiple they are usually symmetrically placed in relation to the ureteral orifices.

Etiology. Some maintain that all diverticula are congenital and base their opinion on the fact that they occur in infants and young children. Others maintain that all are acquired, being the result of back pressure. They point out that they are rarely found when obstruction is absent and that contraction of the vesical neck in young people is more common than was formerly supposed.

The intermediate viewpoint seems most reasonable. Some may exist from birth, notably those at the vault which take origin in a patent urachus, while the remainder are secondary to back pressure, the bladder wall giving way at a point where there is a congenital weakness. Their frequent occurrence in relation to the ureteral orifices being thus explained by absence of longitudinal muscle at these points.

Many writers draw a distinction between those cases of single large diverticula which are met with at any age and those cases of multiple small diverticula so common in prostatic obstruction. The former they term true diverticula and the latter false diverticula or saccules.

They are more common in men than in women, since the former are

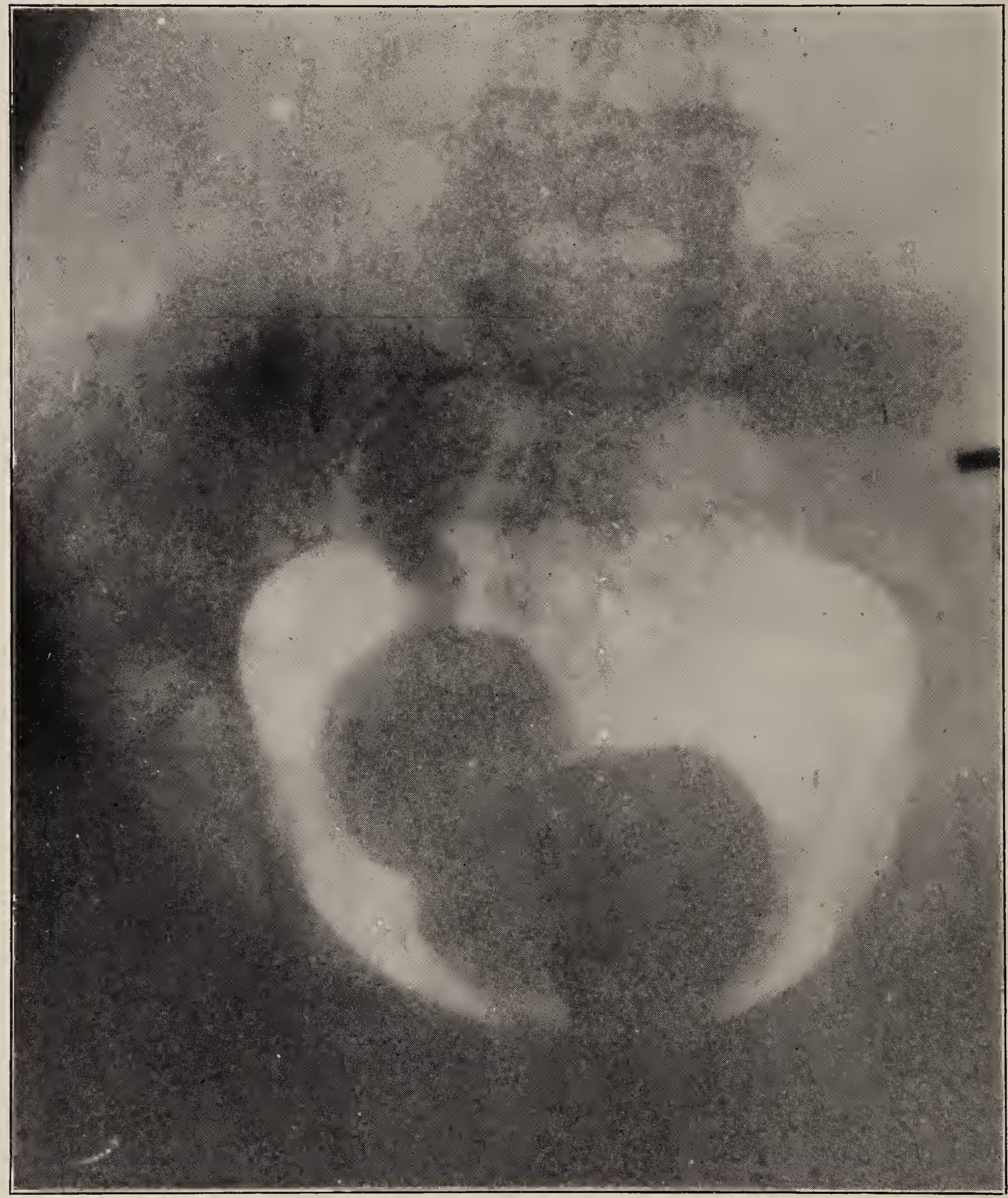

FIG. 4. Cystogram of diverticulum in a fourteen-year-old boy. Note dilated ureter which ran through the floor of the diverticulum. Ureteral reflex is well shown (Author's case).

much more prone to mechanical obstruction, and the majority are met with in the middle-aged.

Hyman found that of 600 reported cases, 25–30 were in children under 10 years of age. Judd and Scholl collected a series of 133 cases, 70% of which were between 40 and 50 years of age, and nearly all were men.

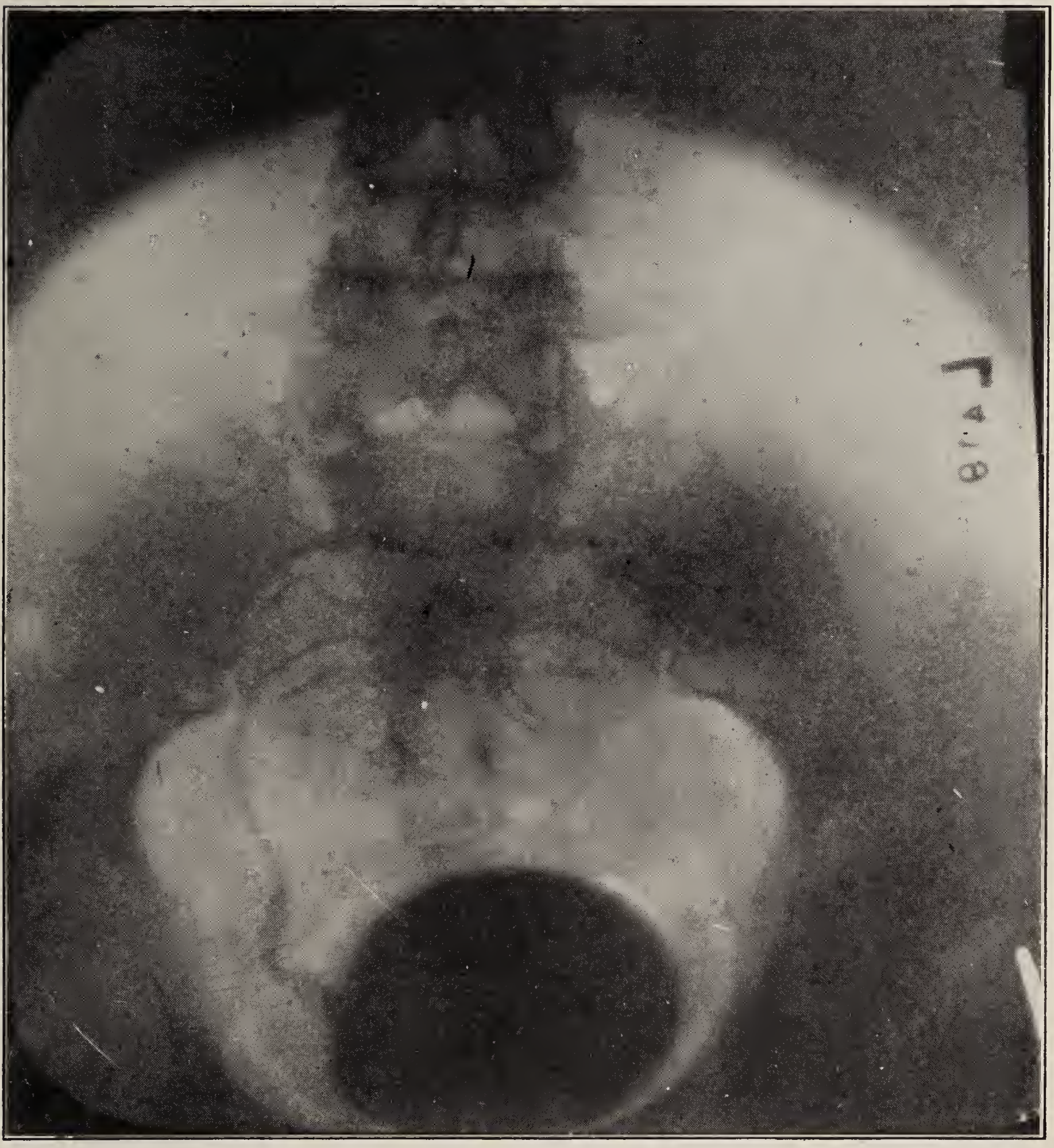

Fig. 5. Post-operative cystogram showing bladder of normal contour, with marked reduction in amount of reflex in right ureter (Author's case).

Eisendrath puts the ratio of males to females as 10 to 1, and this agrees fairly well with the figures of Cabot and Lower, 59 to 5.

Pathology. Diverticula occur most frequently in relation to the ureteral orifices, at the vault and less commonly the posterior wall, rarely the anterior surface. The wall of the diverticulum is composed of the same layers as those which comprise the bladder wall, but the muscle

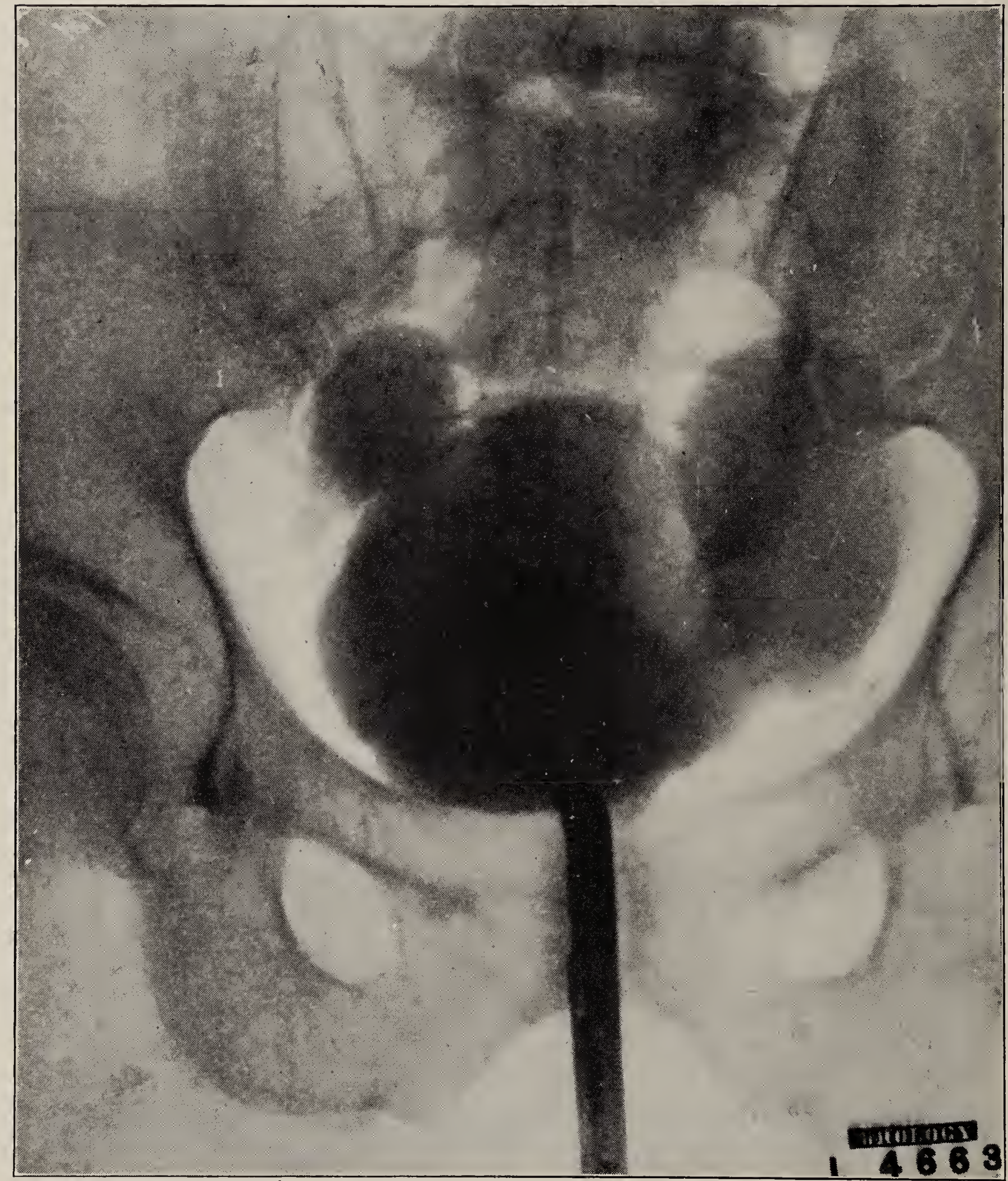

FIG. 6. Cystogram of a case of multiple diverticula in a man, sixty-two years of age, suffering from prostotism. Prostate removed before diverticulectomy (Author's case).

is greatly thinned out and replaced by fibrous tissue. The size of the opening in the bladder gives no very accurate idea of the size of the diverticulum. It is stated that the diverticular orifice has the power of contraction and hence its size may vary from time to time.

Because of the relatively small orifices and few muscle fibres in the

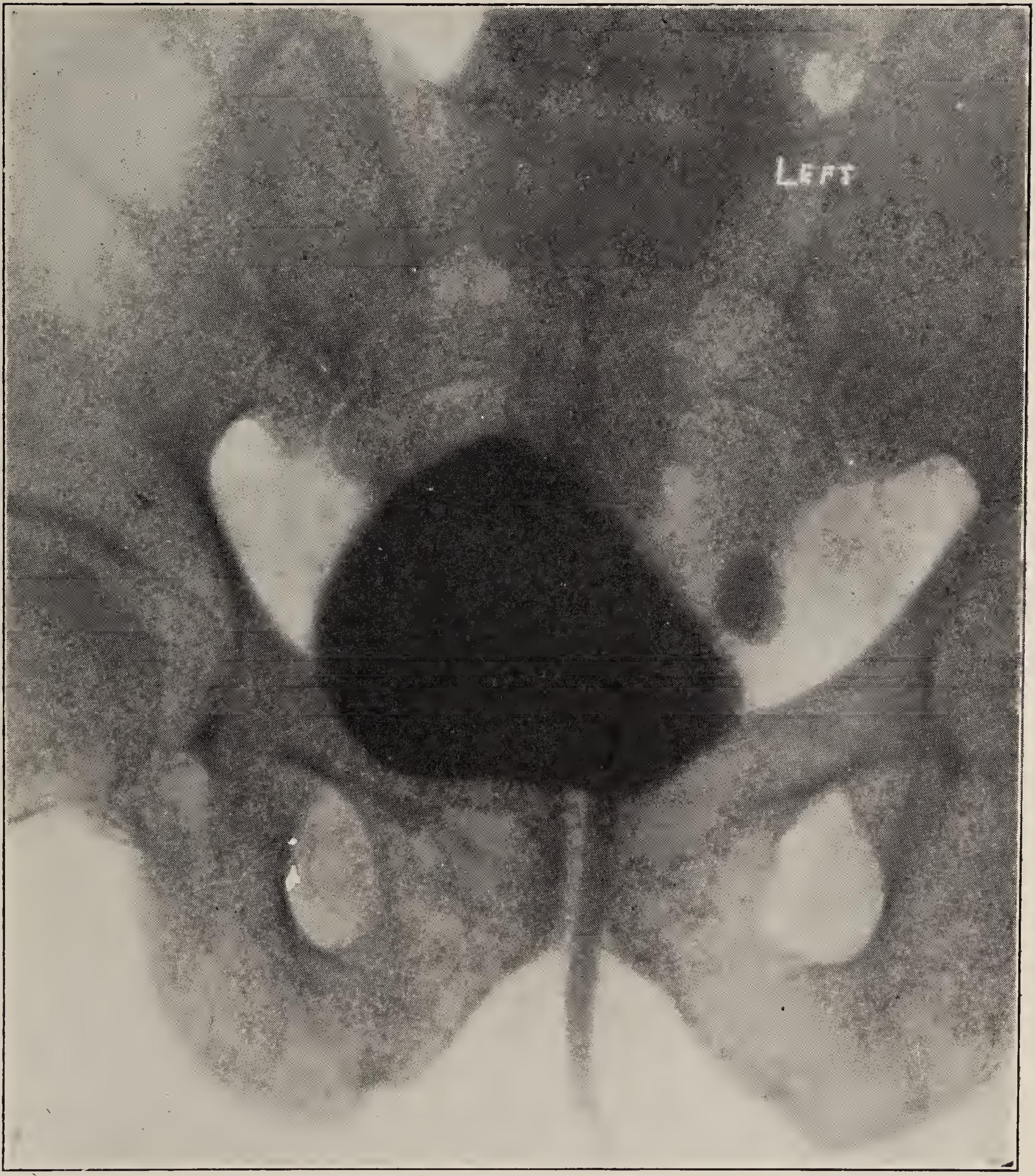

Fig. 7. Post-operative cystogram of Fig. 3 showing contour of bladder. One small diverticulum remains (Author's case).

wall, drainage is poor and this favours stagnation and infection. The wall of the diverticulum is first affected and later the surrounding tissues, leading to a peridiverticulitis. If the contents actually become purulent, perforation may occur with a diffuse pericystitis. This does not frequently occur, however, as the wall is thickened by a previous productive inflammatory change.

Symptomatology. There is no clinical syndrome, characteristic of bladder diverticula. The symptoms are those incident to obstruction to the outflow of urine or those of a cystitis and usually do not appear until infection is superadded. However, in the case of true diverticula, if the patient is closely questioned and is at all observant, some unusual quality in urination will be noted. He may hold an unusual quantity, there may be some frequency, some slight difficulty in voiding, or he may have noticed that the urine is cloudy. In any case, the symptoms are so mild that the patient goes for years before seeking advice and even then the diagnosis may easily be missed unless a careful urological examination is carried out. The appearance of hæmaturia should suggest the possibility of a complication such as stone or tumor.

Associated conditions. The close association of diverticula and ureteral orifices subject the ureter to kinking and pressure. A diverticulum, too, is particularly liable to reflux and if the ureter opens into the diverticulum, its infected contents may thus reach the kidney. In either case infection of the corresponding kidney with pyelonephritis and pyonephrosis is the result. The close association of diverticula and mechanical obstruction to the outflow of urine has been referred to. In adults either prostatism, contracted vesical neck, or stricture is almost a constant finding.

Complications. Infection readily occurs in a diverticulum, from the bladder and its extent and severity depend on its size and the diameter of the opening. Those with a narrow elongated orifice are incapable of emptying their contents and stagnation occurs more readily. The infection may vary from simply catarrhal one to a severe ulcerative lesion. This in turn may give rise to a peridiverticulitis with adhesions to the surrounding structures.

Calculus formation is common in these diverticula. The accompanying factors of infection and stagnation frequently bring about the formation of calculi. These may be single or multiple and are often accompanied by vesical calculi. Dumb-bell shaped calculi partly in the cavity and the remainder in the bladder have been reported.

Neoplasms in a diverticulum have been encountered quite often. These are usually of the epithelial type such as papilloma, papillary carcinoma, or the infiltrating type of carcinoma. Carcinoma associated with calculus formation has been reported several times, and several figures in the chapter on vesical calculi show one of our cases.

Diagnosis. The clinical history and physical examination yield little information that is pathognomonic. Some unusual point in the history may lead one to suspect diverticulum, especially if substantiated by a certain amount of residual urine otherwise unaccounted for. Usually by the time the patient seeks advice the urine contains pus.

The diagnosis is made by cystoscopic examination and cystography.

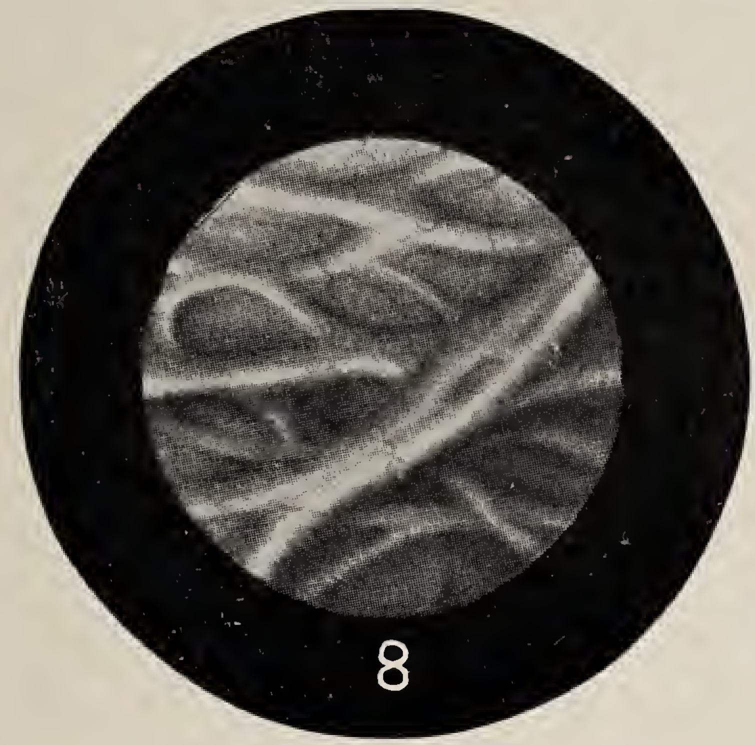

FIG. 8. Cystoscopic appearance of trabeculations of the bladder or false diverticula (Mercier).

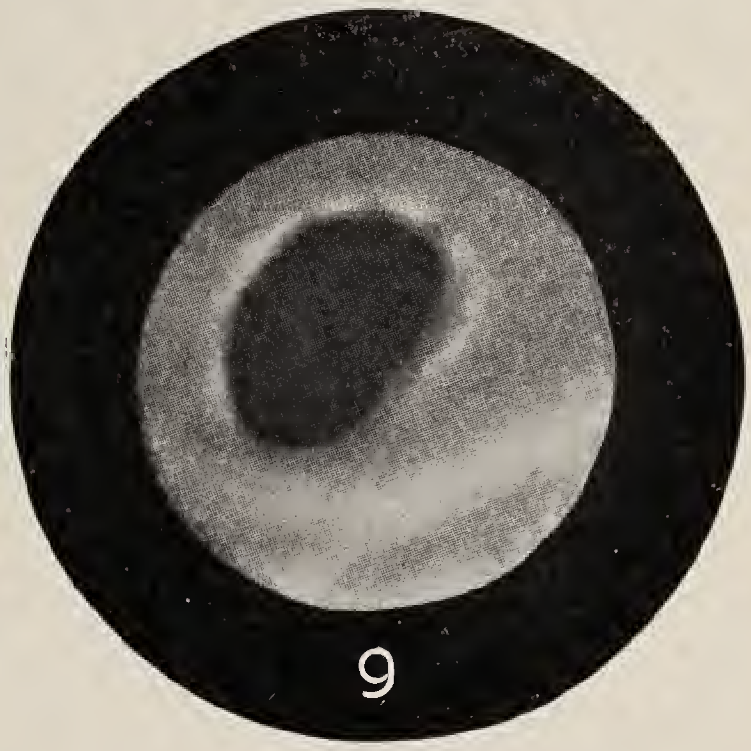

FIG. 9. Cystoscopic appearance of true diverticulum showing dark orifice with clearly defined margin (Mercier).

The false diverticula are readily seen at cystoscopy and are unmistakable, being shallow and lying between prominent ridges of hypertrophied muscle bundles. True diverticula when seen are readily recognizable, but are frequently missed in certain portions of the bladder or in an incompletely filled bladder.

When seen the orifice appears as a dark hole, with a prominent margin. Its size bears no relation to the size of the diverticulum, but a rough idea may be obtained by introducing an opaque ureteral catheter and X-ray. The diagnosis should be further confirmed by cystography with the bladder filled with an opaque medium such as collargol, argyrol or sodium iodide. The exposures are best made with the patient flat in an antero-posterior position and with the pelvis tilted at an angle.

Frequently other diverticula are shown in the cystograms, when a solitary opening only was seen at cystoscopy.

The technic employed by Hinman of first filling the bladder with an opaque medium, then evacuating it and quickly replacing it with air gives a particularly good index as to drainage.

In all cases in which a diverticulum is investigated with a view to operation an opaque catheter should be placed in the corresponding ureter, if possible.

The present-day treatment has been best summarized by Lower in a recent article and is as follows:

> The following surgical procedures for the treatment of diverticula of the bladder have been reported: (1) suture of the orifice of the diverticulum without excision of the sac (Pousson); (2) enlargement of the orifice (Pousson and Chute); (3) radical excision of the diverticulum *in toto* (Young, Hinman, Howard, Lower, Squier, and others).
>
> Surgeons who have had the widest experience in the treatment of the diverticula seem to be agreed that complete excision is the only procedure which leads to permanently satisfactory results. Moreover, there is a unanimity of opinion that, since obstruction in some form is nearly always an important factor in the development of a diverticulum of sufficient size to be brought to clinical notice, the cause of such obstruction should be removed with the diverticulum, if recurrence of the malady is to be avoided.
>
> In our clinic the following operative technique has been adopted: under spinal or sacral anæsthesia, to which analgesia with nitrous oxide-oxygen is added in the case of an apprehensive patient, a suprapubic incision is made and carried down to the bladder. After the peritoneum has been stripped back, the bladder is opened. Exposure of the interior of the bladder is secured by means of flexible retractors and a Cameron light. The diverticulum is located and from its size and position the mode of procedure is determined.
>
> If the extravesical approach is to be used, the collapsed diverticulum is first converted into a solid or semisolid tumor by packing it with a gauze tape. It then becomes a comparatively simple matter to dissect down outside the bladder, lift out the created tumor, sever the attachment of the diverticulum, and close the opening into the bladder. It is important that at the point where the diverticulum has been removed, the bladder be closed with a good muscular apposition, the walls being inverted if possible so as to leave a slight ridge on the inner surface of the bladder rather than a depression at the point from which the attachment of the diverticulum was removed, for such a depression might serve as a starting point for a recurrence of the diverticulum.
>
> One or more small diverticula may be present near a larger one. These are usually left intact, for if the cause of the urinary obstruction is removed and the large diverticulum is excised, the small ones apparently do not increase in size or cause symptoms.
>
> The prevesical space should always be carefully drained. The bladder is closed with catgut sutures, a suture being applied first, to bring the two cut surfaces into apposition, and then an interlocking suture which passes entirely through the muscular coat. An inlying catheter is placed in the urethra and is allowed to remain for several days.
>
> For the removal of a diverticulum in which the ureter is involved, various methods have been employed. Often the ureter will appear to empty into the diverticulum when in reality it has only been pulled over its edge, as it were, and the diverticulum

can be removed without materially disturbing the ureter. When the ureter is included in the diverticulum or injured in the removal it must be carefully transplanted into the bladder. The transplantation should be done in such a way as to retain its physiological function as nearly as possible. A ureter has been transplanted in each of 10 of our cases.

The prognosis to a great extent depends upon many factors; the size, location and number of the diverticula, the extent and severity of the accompanying infection, and the presence of calculus or new growth. The immediate operative mortality as reported by several authors varies from 5 to 8%. If uncomplicated by severe infection or malignancy then the prognosis is favourable. Many surgeons advocate a two-stage or even a three-stage operation in these unfavourable cases, in the belief that after a preliminary drainage operation, or the removal of the urinary obstruction, the patient's condition would be sufficiently improved to stand the major operation.

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SURGICAL ANATOMY OF THE BLADDER

The urinary bladder is a musculo-membranous sac which acts as a reservoir for the urine. Its capacity is about twelve ounces, but it varies greatly even in health and still more so in disease. The capacity of the bladder is, as Guyon has stated, a physical rather than an anatomical consideration.

Situated behind the pubis, the bladder, when not distended, is entirely within the pelvis. It may be described as possessing an anterior and posterior surface, a vault and a floor. The vault and posterior surface are covered with peritoneum which at the base is reflected in the male onto the rectum forming the recto-vesical pouch, and in the female onto the uterus forming the vesico-uterine pouch. Laterally the peritoneum is reflected to the abdominal wall. Anteriorly the bladder is devoid of peritoneum, and it is in relation to the space of Retzius. It is separated by a little areolar tissue from the abdominal wall. As it distends it rises, assuming a globular form, pushes the peritoneum above it, and a part of the anterior surface comes in contact with the abdominal wall.

The floor or base of the bladder is in contact with the upper surface or base of the prostatic gland, and behind this with the seminal vesicles and rectum.

In the female the vesico-uterine pouch reaches to the level of the internal os, and the bladder is in contact with the cervix from there down to the anterior fornix, and then with the vaginal wall in its upper half. The ureters pass on either side of the cervix at the level of the cervico-vaginal junction above the lateral fornices. The absence of the prostate allows the bladder to sink to a relatively lower level in the female, and its relation to the vagina and cervix predisposes it to trauma in operations and parturition.

In children the bladder is at a much higher level than in adults, the internal urethral orifice being about the level of the upper border of the symphysis in early life and gradually sinking until puberty, by which time it is entirely within the pelvis.

The bladder is closely related to several layers of fasciæ and the spaces that they enclose. The most important layers are the pelvic and *Denonvillier's* fascia. The former is made up of a visceral and parietal layer. The parietal portion does not come in contact with the bladder, but the visceral layer, which is also called the recto-vesical fascia, does. *Denonvillier's* fascia is also made up of different layers, namely, the anterior, posterior, and lateral periprostatic fasciæ. The anterior portion extends from the anterior surface of the bladder to the lower border of the posterior surface of the pubis. The posterior layer covers the posterior portion of the bladder. The lateral portion in reality does not come in contact with the bladder but meets the anterior and posterior layers as they run out to the lateral walls of the pelvis.

The most important space that is related to the bladder is the anterior prevesical space or the space of Retzius. It is bounded in front by the symphysis pubis and the anterior layer of the transversalis fascia; behind by the posterior layer of the transversalis facsia; above by fusion of the two layers of the transversalis fascia; below by the anterior periprostatic fascia, and laterally by the fusion of the two layers of the transversalis fascia with the aponeuroses of the transversalis and oblique muscles.

The position of the bladder is fixed below by the urethra, the pelvic fascia and the recto-vesical fascia which binds the prostate and the neck of the bladder to the rectum.

The bladder wall is composed of smooth muscle which is said to be arranged in three layers, two being longitudinal and one circular. The lining mucous membrane is loosely attached and is thrown into folds as the muscular wall contracts. The wall is normally about $\frac{1}{8}$ inch (3 mm.) in thickness, and usually appears flaccid; this has led some to believe that the main factor in emptying is the increased intra-abdominal pressure rather than its own muscular action. The marked hypertrophy met with in obstructive lesions of the vesical neck proves that in these cases the bladder wall certainly assumes a very active rôle.

The trigone is a triangular area, the apex being the internal urethral orifice, and the base the trigonal ridge connecting the ureteral orifices; the three orifices forming an equilateral triangle, each side being about one inch. The mucous membrane here is more firmly attached and does not present the rugæ seen elsewhere. Extending between the ureteral orifices is the interureteric or trigonal ridge, a valuable landmark in cystoscopic work. Its prominence varies, as a rule being more prominent in men than in women, particularly if there is prostatic hypertrophy.

On cystoscopic examination the mucous membrane appears pale with red vessels transversing its surface. As the bladder becomes empty the mucous membrane becomes more red like that of the trigone. The appearance of the ureteral orifices is usually described as a narrow slit, but they vary greatly and may appear absolutely round and as small as a pinhead.

The outlet of the bladder is controlled by a circular band of smooth muscle fibres surrounding the neck, and by the much more important sphincter of the membranous urethra, a voluntary muscle.

The nerve supply from the sympathetic nervous system comes from the upper lumbar segments through the hypogastric plexus. Parasympathetic branches are derived from the upper sacral roots. The superior, inferior and middle vesical arteries are all derived from the anterior trunk of the hypogastric. The veins form a complicated plexus at the base and empty into the hypogastric veins.

The efferent lymphatic channels pass in two main groups; those from the anterior surface to the external iliac nodes and those from the posterior surface to the hypogastric, external and common nodes.

Physiology. The desire to urinate results from a sense of fullness in the bladder and the increase of pressure that it produces. In the average healthy individual the amount of urine present in a bladder when the desire to void is first felt is about eight ounces. Although micturition is a voluntary act yet it is closely associated with a reflex mechanism. When the bladder becomes distended a message is relayed to the urinary centre which is in the lumbar region, and the person then voluntarily presses the abdominal muscles upon the bladder to empty it. Theoretically, therefore, micturition is a reflex act, but in practice it is a voluntary one. It is only in cases of cord lesion or injury that the voluntary factor is absent, and then it is purely a reflex mechanism.

INJURIES OF THE BLADDER

Injuries of the bladder, while relatively infrequent due to protection of the viscus by the bony pelvis, are surgical conditions of the utmost importance, requiring careful diagnosis and swift surgical intervention.

Due to industrialization of nations and the marked increase in the speed and power in the means of transportation, bladder injuries form an increasing percentage of physical injuries.

Physical violence of some sort is the immediate cause of injuries of the bladder, such as crushing injuries, " straddle " falls, other falls, blows and surgical accidents. In the reports of the earlier writers (Bartels in 1878, White & Martin, 1902, Evans & Fowler, 1905) the predominating injuries were described as falls (" straddle " falls) and blows; whereas in the writings of recent reporters (Peacock & Hain, 1926) crushing injuries, industrial casualties and automobile accidents are the most frequent accidents.

The imperativeness of early recognition of injury to the bladder and immediate operation for its relief is clearly shown by the literature on the subject. Bartels in 1878 reported 504 bladder injuries, of which 131 were ruptures involving the peritoneum. Only one of the intraperitoneal ruptures survived and that the only one who had been operated on — a mortality of almost one hundred per cent. The later reports of Evans & Fowler, Peacock and Hain, show a mortality dropping to about thirty per cent.

Injuries of the Bladder fall into two types: Rupture of the Bladder and Wounds of the Bladder.

RUPTURE OF THE BLADDER

Rupture of the bladder means a solution of the continuity of the wall of the bladder through all its coats, not communicating with an external wound.

Etiology. Rupture occurs most frequently in males, probably due to their more active participation in industry. The age is that of the physically active individual though there is today an increasing incidence in children. The author's incidence in children is 7.3%

Rupture is said to occur due to the muscular action of the bladder itself, or to the contraction of the abdominal muscles as in straining at stool or during parturition. Such accidents are rare and occur in bladders markedly distended and weakened by disease. The majority of ruptures are due to direct violence such as crushing injuries, falls, blows and kicks during which there is a sudden increase of the intravesical pressure. Rupture depends upon the amount of the urinary distention and the degree of the violence.

A bladder with long-standing disease and marked distention may rupture with an insignificant injury. Such rupture is most often seen in alcoholics and individuals with cord lesions. On the other hand the bladder undoubtedly frequently escapes, when it is contracted or nearly so, even in violent crushing accidents. The percentage of rupture of the bladder in fracture of the pelvic bones is low.

The rent in the bladder wall is usually found in the postero-superior position. It may, however, be anywhere and in those ruptures due to fragments or spicules of fractured bone it is to be found on the anterior wall of the bladder and about the vesical neck.

Pathology. The pathological findings in rupture of the bladder depend upon whether or not the peritoneum covering the viscus is involved in the tear. Two types of rupture are recognized: Intra-peritoneal where the rent involves the peritoneum and extra-peritoneal where that structure is not torn through.

Intra-peritoneal rupture usually results when the bladder is quite distended and violence is applied to the lower abdomen. The tear is usually found in the postero-superior position. Urine and blood are rapidly extravasated into the peritoneal cavity, causing peritonitis speedily, especially if the urine is infected at the time of the accident.

Extra-peritoneal rupture may be said to be of two types. In one the rupture takes place below the peritoneal reflection. Urine and blood extravasate into the space of Retzius. Extravasation tracks upwards toward the umbilicus, laterally as far as the ischial spine on each side and downwards to the bladder neck. In the other the tear, also below the peritoneal reflection, is due to laceration of the bladder by fragments of the pelvic bones. The rupture is usually found on the anterior wall about the neck of the bladder. Here extravasation occurs about the vesical neck, spreads through the cellular tissue of the pelvis to accumulate between the bladder and rectum. It is in this type that there occurs most often a rupture of the urethra as well.

Symptomatology. The earliest symptoms are those due to the injury, the later ones are those due to extravasation and infection.

Immediately following the accident there is shock of variable degree. There may be little or much, even so great as to cause death. Usually much helplessness is complained of and the patient is unable to walk or does so with great difficulty.

There may be partial or complete inability to void. If the patient does void, it is usually only small in amount, blood stained and causes considerable pain. Blood oozing from the urethra indicates that the urethra has been lacerated as well.

There are usually ecchymosis and contusions of the lower abdomen, pubes, genitalia and sometimes the thighs. There is also marked local tenderness.

At this stage it is impossible to tell the extent or situation of the rupture. If the rupture is intra-peritoneal the symptoms of peritonitis rapidly come on, particularly if the urine is infected at the time of the rupture. Great abdominal distention sets in; there is generalized abdominal tenderness, rigidity of the abdominal muscles, high fever and rapid pulse. When the tear is extra-peritoneal the picture is that of extravasation with infection — chills, fever, marked tenderness and doughiness of the parts with gangrene and sloughing.

Diagnosis. The diagnosis is made on the history, the shock, the local pain, tenderness and swelling, the urinary disturbance and the presence of blood in the urine. It must not be forgotten that blood in the urine may be due to an associated laceration of the urethra, to a bladder lesion other than rupture or to an upper urinary tract lesion.

The determination of the fact of rupture by the passage of a soft rubber catheter or other urethral instrument, through the urethra to the bladder, the injection of a measured amount of sterile fluid and the recovery of the fluid is an unreliable test. The tear in the bladder may be so small or so situated that the fluid can be recovered.

Early the diagnosis of rupture is more difficult than later after peritonitis has declared itself or after extravasation and sepsis make clear extra-peritoneal tear.

Rupture of the bladder must always be excluded in every fracture of the pelvic bones.

Treatment. Immediately the diagnosis of rupture has been made the bladder must be explored, preferably by suprapubic incision. Even in cases where the diagnosis is in doubt it is better to explore the bladder early than to run the risk of a possible peritonitis or sepsis.

If the patient is in marked shock, cardiac and respiratory stimulants, intravenous saline therapy and even transfusion may have to be resorted to.

The type of anæsthesia will depend upon the degree of shock. Sometimes a light ether anæsthesia acts as an actual stimulant. Usually the operation can proceed under local anæsthesia to the exposure of the bladder. At this stage a general anæsthesia, nitrous oxide-oxygen or even light ether, may have to be resorted to if much retraction becomes necessary.

The bladder is found contracted. It is opened and the rupture identified.

If the peritoneum is found to be involved, the peritoneal cavity is opened, mopped free of all urinary and blood extravasation. The peritoneal tear is sutured independently of the bladder tear and the peritoneal cavity is drained separately. If the rent in the bladder is high, and it usually is in this type of rupture, it may be utilized for drainage of the bladder, otherwise the bladder is drained by tube at the vault.

In extra-peritoneal rupture the rent in the bladder is sought and is sutured unless it is small. It is imperative to drain the bladder.

In both intra- and extra-peritoneal tears extravesical areas of extravasation must also be drained.

Prognosis. The prognosis of rupture of the bladder depends upon the severity of the injury and the speed with which intervention takes place. The mortality rate in late cases is one hundred per cent; in those operated on early it is about thirty per cent.

Complications and cause of death. The complications of rupture are usually those due to the associated conditions of peritonitis, sepsis, bronchopneumonia and fracture of the pelvic bones.

The cause of death is shock, hemorrhage, peritonitis and sepsis.

WOUNDS OF THE BLADDER

Wounds are complete lacerations of the bladder wall, produced by penetrating instruments or missiles which enter through the body surface.

Etiology. Bladder wounds are frequently multiple and may involve both the intra-peritoneal and extra-peritoneal surfaces at the same time.

Most of these wounds are produced by bullets or shell fragments, but any sharp or blunt penetrating instrument may pierce the bladder. Stab wounds are rare. Surgical operations on neighbouring organs may accidently involve the bladder; notably in the course of operation on the pelvic organs and during herniotomy. The common region of entry is the perineum, the suprapubic region and the obturator foramen — all sites of vulnerability due to lack of bony protection.

Symptomatology. The symptoms caused by bladder wounds are the same as those for rupture of the bladder. Here, in addition, there is an external wound. Peritonitis and extravasation follow as in the case of rupture.

Diagnosis. The diagnosis is made on the history, the external wound, and the signs and symptoms as described above under rupture of the bladder. In the case of bullets or shrapnel X-ray may show them lodged in the bladder region. Urine may escape from the surface wound.

Treatment. Once the diagnosis is made exploration of the bladder should be immediate. Ether anæsthesia may be used. The bladder must be drained, the extra-vesical areas of extravasation must be drained, and the peritoneal cavity, when that is involved, must be drained. It is important especially in the latter contingency that all particles of foreign material, bits of clothes, the bullet or shrapnel, etc., be removed.

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VAGINO–VESICAL AND UTERO–VESICAL FISTULÆ

Urinary fistulæ bring about a condition which makes the patient truly miserable and becomes a source of great worry to all thinking genito-urinary surgeons. It may be due to exstrophy of the bladder, to transplantation of ureters in the skin, to a traumatic sinus from the ureter to the vagina, or to a traumatic utero-vesical, vagino-vesical or urethro-vaginal openings.

Utero-vesical, vagino-vesical and urethro-vaginal fistulæ are the result of difficult parturition, colpotomy wounds, abdominal operations and more particularly hysterectomy, radium or cautery treatment for cancer.

In general, obstetric management and operative treatment have both greatly improved in later years, but from the records in the majority of large clinics in America and in Europe there is abundant evidence that we still have such fistulæ to combat. In a long series from the Mayo Clinic, Judd reports patients who had six and seven previous operations. One of our patients with a high vesico-vaginal fistula had undergone seven operations, another twelve operations. One woman with complete loss of the floor of the bladder from cervix to urethra inclusive, had eighteen operations before coming to our service.

That the best method of operation is still undecided is deduced from the arguments of many prominent surgeons. Trendelenburg, Marcy, Legueu and others claim advantages for the transperitoneal route; Paris, Francey and others from the transvesical route; Schulze-Berge advocates operation through the pre-vesical space; Bachrach upholds the transplantation of the ureters in the skin. Several surgeons believe in the transplantation of the ureters in the bowel; Nighoff and Mayo argue the superiority of the purse-string suture with traction to the bladder; Latzko, Rosenski, Bertino, Ferroni, MacLean, Ward, Judd and Kelly support many different varieties of the vaginal route. For suture material some use silk, some catgut, some silkworm gut and some silver wire.

The suprapubic operation is as a general rule more suitable for uretero-vaginal fistulæ but even at its best it is more severe for vesico-vaginal and vesico-cervical, and it has a much higher mortality than when these conditions are approached from below. To Trendelenburg is due the credit for first using the suprapubic operation for the cure of these fistulæ. His work was published in 1890. In 1902, Kelly advocated the employment of the knee-chest posture in order to obtain a good exposure of the vaginal vault. He opened the peritoneal cavity by a wide transverse incision. Eleven years later he contended that the lithotomy position was superior to the knee-chest posture.

The method to be employed in each case must, of course, be determined by a careful consideration of the conditions present and by the experience of the operating surgeon. In some cases, mainly those associated with the ureter, the suprapubic is the only choice, but in all others the vaginal route should be tried first.

The apparent ease with which these fistulæ may be closed is too often very deceiving to the inexperienced and unless definite procedures are followed, the results are often very unsatisfactory.

Before any operative procedure is undertaken the ureteral openings and the opening of the fistula in the bladder should be definitely located. If the opening is very small and free of the ureters, the high frequency current may be tried. All possible facts regarding the course and position of the sinus should be ascertained before treatment is considered. An effort should also be made to get the tissues in the best possible condition

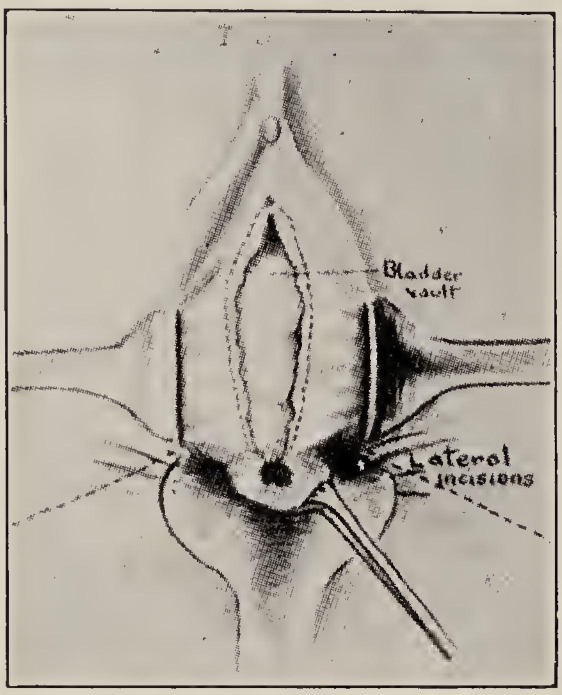

FIG. 10. Drawing of extensive laceration of the bladder extending from the urethra to the cervix uteri in girl sixteen years old following forceps delivery. Note incision about edge of laceration. Complete recovery in twenty-one days (Author's case).

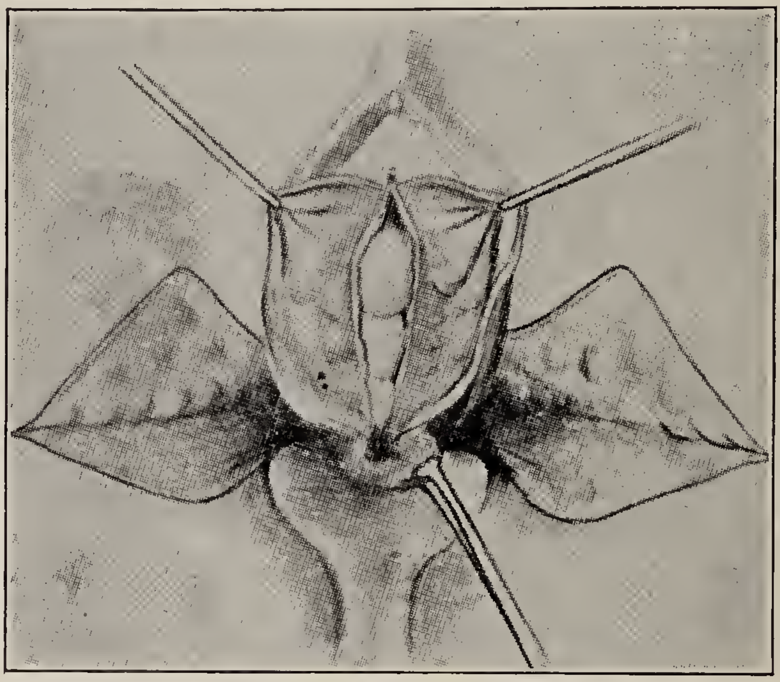

FIG. 11. Drawing of same case showing next important steps in the operation of plastic repair. Lateral episiotomy incisions through the vaginal wall allowing mobilization of the operative field. Wide and free dissection of the vaginal wall from the bladder wall (Author's case).

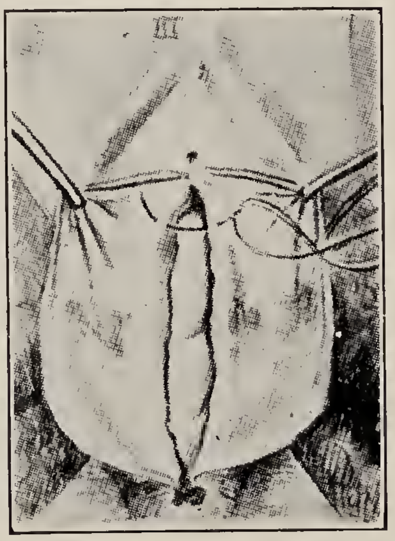

FIG. 12. Drawing showing the invagination by interrupted suture of the opening in the bladder (Author's case).

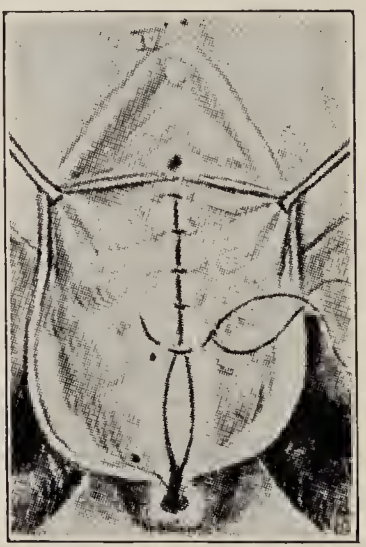

FIG. 13. Drawing showing next layer of sutures over the original invaginating suture line (Author's case).

for healing; this latter often requires considerable time as the mucous membrane of the vagina, bladder and labia may be much excoriated, infected, and coated with deposits of urinary salts.

One of the greatest difficulties encountered is trauma to the vesical neck with partial or complete loss of the vesical sphincter. If the opening of the bladder is high in the vaginal fornix, and especially if there is much scar tissue, it is sometimes difficult to obtain sufficient exposure for satisfactory dissection. This consideration led us to make two free lateral incisions in the perineum, lateral episiotomy wounds, with the same objective as Ward had with his paravaginal incision. It is surprising to what extent this will facilitate the bringing of the cervix and the fornix in full exposure in the operative field. With catheters in the ureters and a catheter through the fistula from the bladder to the vagina, as guides, it is much safer to proceed with the dissecting of the vaginal from the bladder wall. Grasping the cervix with a tenaculum, we have used a long incision, antroposteriorly, in the vaginal vault surrounding the sinus. The vagina is now freely dissected from the bladder wall until the bladder hangs loosely and can be easily invaginated into that viscus. Unless this dissection is thoroughly carried out the possibility of cure is remote. With a small curved needle and a moderately fine catgut the sinus is invaginated into the bladder with interrupted sutures or, if the fistula is small, with the purse-string suture. These are further reinforced by one or more lines of Lembert sutures. The vaginal wall is then loosely sutured over this with fine catgut. If the sinus is in the sulcus at the cervix, the denuded cervix may be used to make body for our suture; if the urethra has been torn, it is well to dissect free both the sides, and, if possible, to grasp some of the sphincter fibers or the scar tissue to which these are attached and to suture one side to the other to get a central body to give control. It is obvious that the bladder flaps should be free and loose and easily approximated in order that no tension may be exerted on the suture. We have used plain catgut entirely in these cases. We believe that the sloughing of the flaps or about the wound is too often due to tension on the sutures. The lateral perineal incisions are now sutured and the vagina is carefully packed with iodoform gauze to obliterate any dead space between the vagina and the bladder wall and also to elevate the floor of the bladder in order to bring the line of suture, if possible, to the ridge of a watershed.

The post-operative care is most important. A little carelessness at this point may destroy all hopes of final success. Following the operation we have emptied the bladder, by means of a retention catheter or frequent catheterization. One of our patients urinated spontaneously after the second day without any undesirable effect. All our patients were kept in bed for a period of from two weeks to eighteen days after operation.

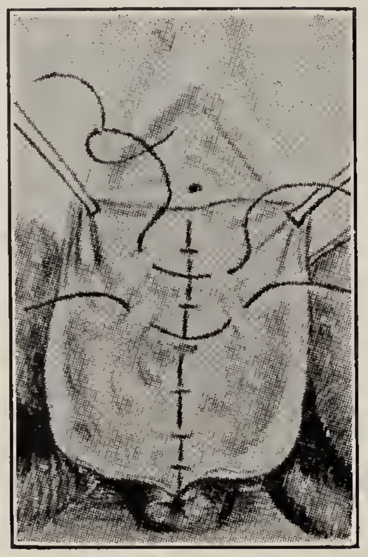

FIG. 14. Drawing showing further reinforcing of primary suture lines by others utilizing denuded areas (Author's case).

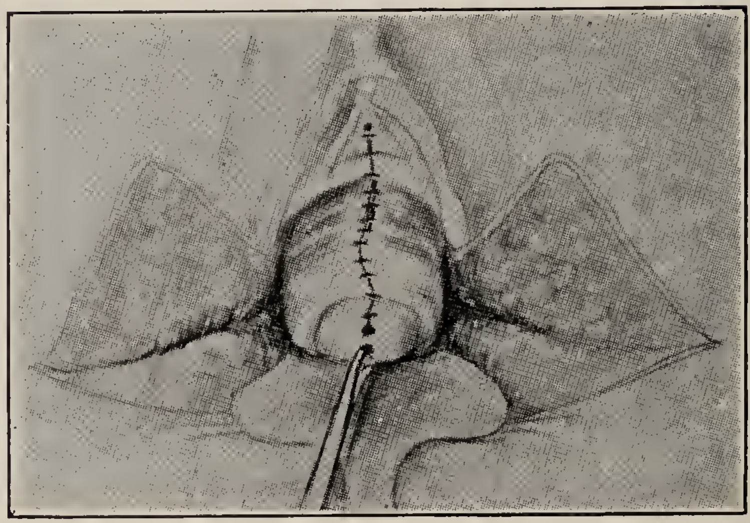

FIG. 15. Drawing showing completed suture line closing vaginal incision (Author's case).

In the operative handling of these types of urinary fistulæ the important points are:

1. Pre-operative cleansing of the parts.
2. Attacking the condition from a urological point of view.
3. Definite diagnosis with location of openings in the bladder and the relation to the ureteral orifices.
4. Lateral perineal incisions, especially for fistulæ high in the vagina or uterus.
5. Free separation of the vaginal from the vesical wall, particularly in the cases with dense scar.
6. Multiple layers of suture with invagination of the bladder into the viscus.
7. Vaginal packing to elevate and support the suture line.
8. Post-operative judgement and care.

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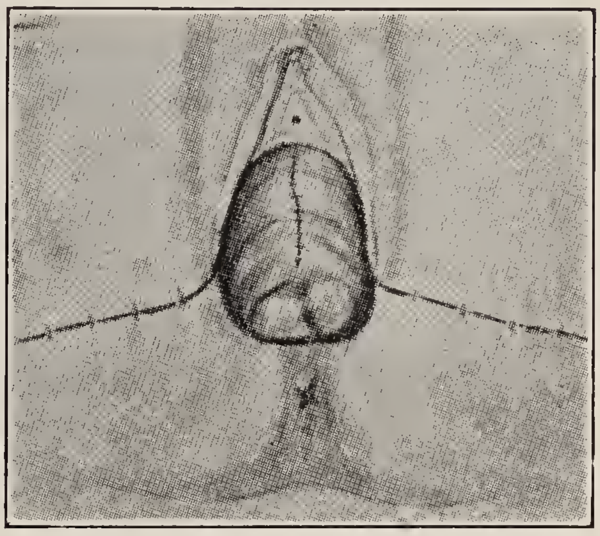


FIG. 16. Drawing showing completed operation with lateral vaginal incisions sutured. Next important step is to pack vagina so that suture lines form the ridge of a water-shed (Author's case).

Inflammations. Although several different types of inflammation of the bladder have been described, yet clinically a small number of them are recognized. For simplicity the following classification will be used:

(1) Acute cystitis. (2) Chronic cystitis. Pericystitis will be discussed under the group of chronic cystitis as every case of cystitis of long standing almost always has a pericystitis associated with it. Tuberculous cystitis is also a chronic inflammation of the bladder, yet on account of its extreme interest and importance will be discussed under a separate heading.

Etiology. The bladder is very resistant to infection and hence a cystitis is never considered as a primary disease. Although organisms are frequently found in the bladder, yet an inflammation does not result unless there is some predisposing factor favouring their development. The mere presence of organisms in the bladder is usually insufficient to produce an inflammation of that viscus. In discussing cystitis, therefore, it is necessary to consider the predisposing factors, the exciting causes and the routes of infection.

Predisposing factors. These are by far the most important items in the etiology of a cystitis. Amongst them we have:

(1) Retention of urine due to prostatism or stricture of the urethra.

(2) Foreign bodies in the bladder, such as stone.

(3) Disease of the bladder wall as new growths, tuberculosis or simple ulcer.

(4) Trauma caused by instrumentation or accident.

(5) A disease extending into the bladder from neighbouring organs or tissues. The most important of which are the rectum, urethra, ureters, prostate and pelvic cellular tissue.

(6) Paralysis of the bladder from injury or disease of the nerves or nerve centres.

(7) Irritating drugs either taken orally or introduced into the bladder per urethram.

(8) Disease of the kidney such as pyonephrosis, or pyelonephritis.

One of the above conditions is absolutely necessary to produce an inflammation of the bladder. The mere introduction of bacteria will not in itself cause a cystitis. This is best exemplified by the fact that urethral instrumentation and bladder catheterization when performed gently will cause no harm, and yet the urethra is never free from organisms. On the other hand, if bladder has been distended for any length of time or if there is a residual urine due to prostatism, for example, catheterization will invariably cause an inflammation.

Bacteriology. The microörganisms are the exciting causes that are responsible for the production of inflammatory conditions of the bladder, and they may be divided into two groups: (1) Those that cause an acid cystitis. The most important are the colon and typhoid bacilli. (2) Those that cause an alkaline cystitis such as the staphylococcus, the streptococcus and the proteus group.

Hill[13] analyzed 356 cultures of infected urines and found a greater incidence of cocci than colon bacilli. Mathé and Belt[23], on the other hand, found a much greater incidence of the colon bacilli — porportion of almost 6:1. Seng,[35] working on the urinary tract of ante-partum and post-partum women, has also observed the marked frequency of colon bacilli in the urine. We agree with the latter observers, for in our experience by far the commonest organisms found in infected urine are the colon bacilli.

Portals of entry. (1) *Urethra.* Organisms are normally present in every urethra and during instrumentation may be conveyed to the bladder.

(2) *Kidneys.* Descending infection from the kidneys by way of the ureters is probably the most frequent cause of cystitis. This may result either from infection in the kidney proper as in pyonephrosis, or from the blood stream via the kidney.

(3) *Blood stream and lymphatics:* Direct infection of the bladder through the blood stream and lymphatics is undoubtedly a rare occurrence. It seems more probable that the infection is first conveyed by the blood stream to the kidneys and then to the bladder.

(4) *Extension from adjacent structures.* An inflammation of the bladder may result from the direct extension of a disease of an adjacent organ. Malignant disease of the rectum and uterus, vesico-vaginal fistula and pelvic and prostatic abscesses are the most frequent causes.

Whether direct migration of pathogenic organisms from the rectum to the bladder takes place is a question which still remains undecided. One must consider the relative frequency of cystitis in cases of typhoid fever and the discovery of the bacillus typhosus in the urine. The probabilities are, however, that these infections result from the direct invasion of the bacteria from the blood stream by way of the kidneys.

Pathology. *Acute Cystitis. Gross.* In the early case one sees a congestion of the mucous membrane which is most marked about the trigone and vesical neck. The fine branching capillaries which are so characteristic of a normal bladder mucous membrane are lost and in their stead there is œdema and redness. Later the epithelial cells begin to desquamate and one may now see small petechial hemorrhages and even small minute ulcers. If this persists the entire mucous membrane may become ulcerated and the bladder wall infiltrated.

Histology. In early and mild cases there is observed œdema swelling and desquamation of the epithelium of the superficial layer with an infiltration of polymorphonuclear leucocytes. Later the submucosa is also involved, showing engorgement and dilatation of blood vessels. As the disease progresses small abscesses are seen. These may rupture and form minute ulcers. The musculature of the bladder is never involved to any great extent in the inflammatory process. It may hypertrophy but there is very little evidence of infiltration with inflammatory cells. This important point in the pathology of acute cystitis has been conclusively shown by Motz and Denis.[27]

Chronic Cystitis. Gross. In long-standing cases the bladder wall is either thickened or thinned and the bladder capacity is thus either diminished or increased. Usually the former condition is found and the organ is unable, therefore, to undergo its normal distension. When there is associated an obstruction, as in prostatism, one will usually find trabeculations and diverticula.

The mucous membrane no longer has its smooth pinkish appearance. It becomes mottled, darker in color and irregular. There are usually present elevations, bullous œdema, and very often papillary projections which may resemble a new growth. Areas of ecchymosis and pigmentation are very often seen and occasionally there is observed phosphatic material adherent to the inflamed mucous membrane, known as incrusted cystitis. A picture commonly seen in chronic cystitis is the so-called cystitis cystica. This condition is due to the formation of pseudo glands which secrete and form cysts. This process has been carefully studied by Klebs, Limbeck,[22] Dogiell[4] and Rokitansky. In rare cases a chronic cystitis becomes destructive and there is present the condition known as pseudomembranous, ulcerative or gangrenous cystitis.

Histology. The epithelium of the mucous membrane is partially or completely lost, depending on the severity of the cystitis. At times the entire mucosa is destroyed and the bladder cavity is then lined by connective tissue. Below the mucosa there are present dilated blood vessels, lymphoid and connective tissue cells.

In the early stage the musculature is hypertrophied but later it is gradually replaced by dense scar tissue. The late thickening of the bladder wall is therefore due to a proliferation of connective tissue. The same process takes place when the bladder wall is thinned out but there is present less scar tissue.

COMPLICATED FORMS OF CHRONIC CYSTITIS

Leukoplakia and malakoplakia. These are extremely rare lesions appearing in a chronically inflamed bladder. Kretchmer[20] was able to collect and report 44 cases in 1920. The lesions result from proliferation and keratinization of the epithelial cells. They appear as multiple clear cut plaques and at times resemble condylomata. The peculiar lesions are thought to be due to tuberculosis, gonorrhœa, stones and foreign bodies. Some authors consider syphilis as an important etiological factor.

Pseudo membranous cystitis. This condition is also a very rare occurrence and is present in a severe and destructive form of cystitis. The lesion appears either in disseminated plaques or in the form of confluent exudates. The pseudo membranes are dirty greyish in color and are composed of fibrin, leucocytes, bacteria and broken down tissue. Occasionally one or several membranes are detached and are passed in the urine. Lime salts are very often deposited on the membranes and there may be superficial necrosis.

Ulcerative cystitis. The varieties of ulcer observed in chronic cystitis vary greatly in size, shape, appearance and number. Besides the tuberculous, luetic and solitary ulcers which will be described separately, there are others resulting from a severe form of cystitis, trauma, chemical reagents and even typhoid fever.

In a severe inflammation of the bladder the ulcers may be very destructive, causing hemorrhage and marked necrosis. Traumatic ulcers are not uncommon and are due to rough instrumentation or to thermic injury following fulguration of a bladder tumor. Typhoid ulcers are extremely rare.

Gangrenous cystitis. The end result of a pseudo membranous or ulcerative cystitis is that of partial or complete gangrene of the bladder. This serious condition is extremely rare and occurs only in very destructive forms of cystitis. The condition has been described very fully by O'Neil[29] Stoeckel[36] and Mezard.

Incrusted cystitis. This is a very resistant form of alkaline cystitis. It is thought to result from a combination of infection, destruction of the mucous membrane and strong alkaline urine. The first case to be reported was by Caulk[3] in 1914 at the Association of Genito Urinary Surgeons.

The organisms which have been isolated from the condition are the staphylococci, colon bacilli, B. Proteus, tubercle bacilli and micrococcus urea. Hagar and Magath[9] have proven the direct relation of a special organism called *Salmonella Ammoniæ* to the incrustations. Kearns[18] in 1928 reported a case from which Bacillus Proteus ammoniæ was isolated. This same author calls attention to the recent report of Roche of a case of incrusted cystitis in which there was typical evidence of Bacillus Proteus ammoniæ infection.

Incrusted cystitis appears either as flat incrustations or in the form of elevated tumorlike masses. Either form may be associated with vesical calculus, prostatism, stricture of the urethra, tuberculosis, gonorrhœa, or pyelonephritis. The elevated type is the less common of the two and is due to an almost constant precipitation of phosphatic material on the incrusted ulcer.

A very striking characteristic of this type of cystitis is the marked resistance to treatment and the great tendency to recurrence.

Cystitis cystica. This form is commonly seen in chronic cystitis. It results from the formation of pseudo glands which secrete and form cysts. Some authors like Zucker-Handl consider this type of cystitis as the precursor of carcinoma.

Cystitis emphysematosa. This condition is extremely rare and is most common in females. Up to the present only 22 cases have been reported in the literature. The lesion is characterized by a cystitis plus the presence of gas containing cysts or vesicles in the wall of the urinary bladder. The cause is unknown. Mills[25] in 1930 discusses the condition, reviews the literature and reports the available cases. This author stresses that gas gangrene and this type of cystitis are not related in any way.

Symptomatology. The symptoms of a cystitis are the same whether acute or chronic, mild or severe. They vary in degree only and will therefore be considered together. The outstanding ones are frequency, urgency, and painful urination. Occasionally there is also hæmaturia. The cardinal sign is pyuria and that is a constant finding.

Frequency and urgency. These symptoms are usually the first to make their appearance. They are present both by day and night and are aggravated both by motion and exposure to cold. In severe forms of cystitis there is an almost constant desire to void.

Pain. This symptom in a very common one and may be present before, during or towards the end of urination. Occasionally there is also a dragging pain in the suprapubic area and the perineum.

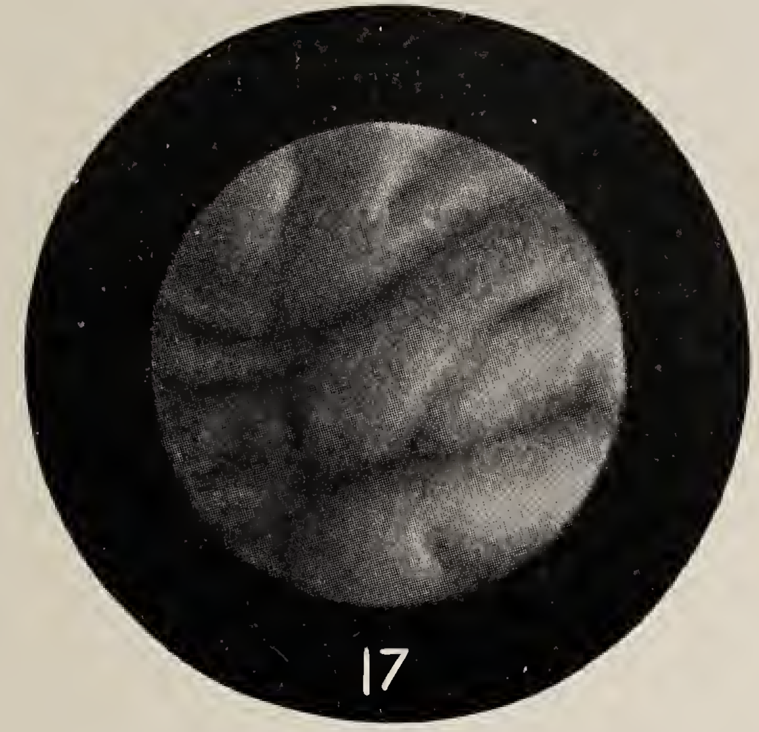
Hœmaturia. Blood in the urine is not a constant symptom. When present it usually occurs during and towards the end of the act of urination. Occasionally the hæmaturia is quite profuse. This is particularly noticeable in the ulcerative and incrusted forms of chronic cystitis.

Pyuria. Pus in the urine is a constant finding. Without pyuria there is no cystitis. In gangrenous or incrusted cystitis the urine is alkaline, foul smelling and contains particles of slough, membrane and mucus.

Diagnosis. Again it must be emphasized that a cystitis is always secondary to some other pathological condition. It is, therefore, most essential to determine the predisposing factor. Too often is a diagnosis of cystitis made on the history and the presence of pus in the urine, without attempting to ascertain the cause of the inflammation. It is true that a history of frequency and dysuria and the finding of pus in the urine attract our attention to the bladder, but it is our duty to proceed further in order to arrive at a correct diagnosis.

Our most important aid in the diagnosis is the cystoscope. It is by means of this instrument that one can determine accurately the cause, the type and the degree of the inflammation.

Cystoscopic appearance. (1) *Acute Cystitis:* The characteristic fine capillary network of the normal bladder is lost. One now sees marked redness and swelling of the mucous membrane. (Fig. 17.) The inflammation may involve the entire bladder or only a portion of it, and very often it is associated with small areas of ulceration. In very severe cases there



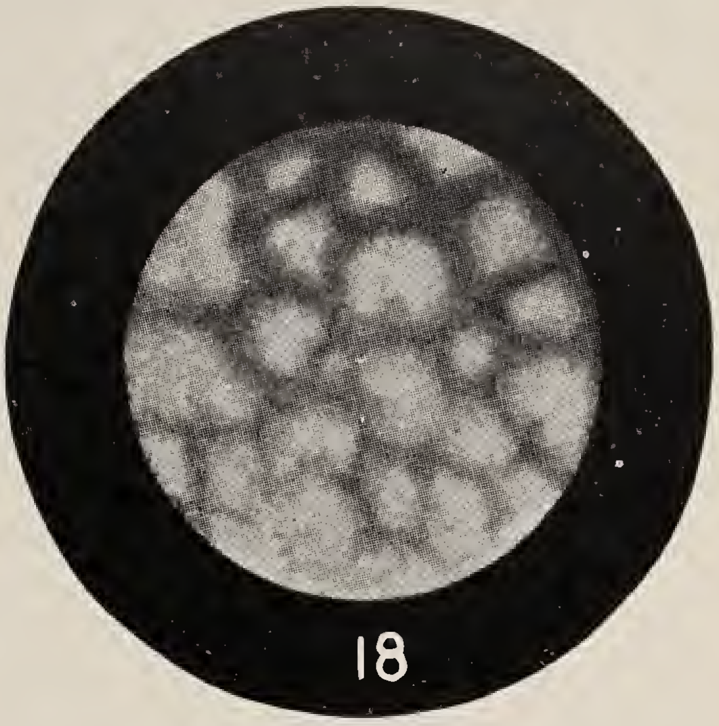
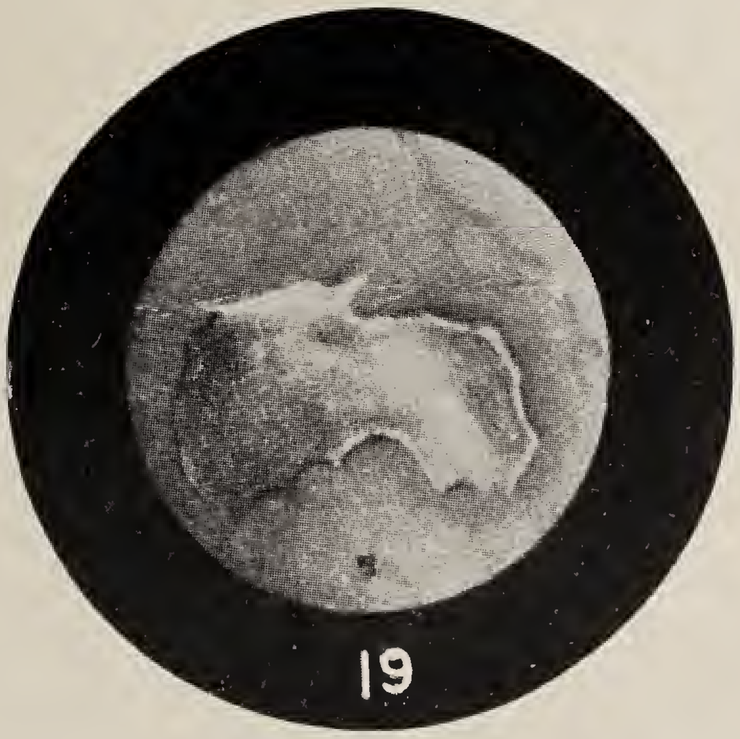


Fig. 17. Cystoscopic picture of an acute cystitis. Note the absence of the fine capillaries. The mucous membrane is reddened, swollen and irregular (Mercier).

Fig. 18. Cystoscopic appearance of a chronic cystitis. The mucosa is swollen, irregular and has lost the normal capillary network of vessels (Mercier).



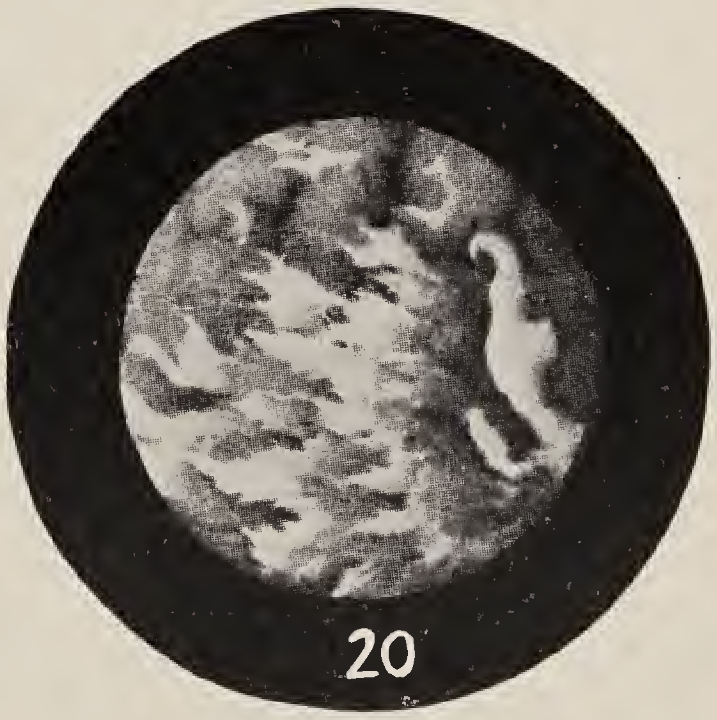


Fig. 19. A whitish plaque of leukoplakia seen in a chronically inflamed bladder (Mercier).

Fig. 20. Cystoscopic picture of pseudomembranous cystitis. Note the whitish yellow membranes in a severe chronic cystitis (Mercier).

is present bullous œdema about the trigone and vesical neck. Very often there are small petechial hæmorrhages and areas of ecchymosis. The ureteral orifices may be normal or swollen, reddened, and even ulcerated. Occasionally on account of the marked swelling of the mucous membranes the orifices are not visible.

(2) *Chronic Cystitis:* In a chronically inflamed bladder one finds as a rule that distention of the viscus is definitely limited and very often a patient will not tolerate more than an ounce or two of fluid.

The appearance of the normal mucous membrane is greatly altered. (Fig. 18.) It is irregular, swollen and granular, and there is a definite mottling due to submucous hæmorrhages. In long-standing cases bullous œdema is almost always present, and is particularly prominent about the trigone. Occasionally there are localized areas of hyperplasia of the mucosa and submucosa. Braasch and Hurley[1] in a recent study used the term granulomas to describe these areas. Frequently there is an abundance of granulation tissue taking the shape of villous processes. The picture now resembles a bladder neoplasm. In old cases, particularly in those associated with vesical neck obstruction, trabeculations and diverticula are almost constant findings. Very often one sees small cysts in a chronically inflamed bladder — the condition is known as cystitis cystica.

In leukoplakia and in malakoplakia the lesions appear as whitish or yellowish plaques which are either smooth or heaped up. (Fig. 19.) There is always associated a chronic inflammation of the bladder.

The cystoscopic appearance of a pseudomembranous cystitis is that of a very severe inflammation of the bladder complicated by dirty yellowish raised plaques which are the pseudo membranes. (Fig. 20.) These membranes are occasionally seen floating in the bladder.

In ulcerative cystitis the bladder picture varies greatly, depending on the size, shape, appearance and number of the ulcers. Fenwick[6] first pointed out that the size and shape of an ulcer depend on whether the bladder is distended or relaxed. If the part of the bladder that is affected is stretched the ulcer may appear as a superficial erosion only. On the other hand, if the bladder is empty the lesion appears heaped up and may at times resemble a small growth.

Traumatic ulcers usually appear as superficial irregular erosions with yellowish bases and always have an area of inflammation about them. Typhoid ulcers are extremely rare and resemble very closely the lesions found in the intestine in typhoid fever. The ulcers are small, punched out and have a clean base.

The cystoscopic picture of gangrenous cystitis is one of a very advanced and destructive form of chronic cystitis. In some cases the entire mucous membrane may separate, leaving a dirty greyish or whitish surface which is often covered with salt deposits.

In incrusted cystitis the bladder is usually inflamed throughout and there is present considerable œdema. (Fig. 21.) Adherent to the bladder wall are masses which appear either as flat incrustations or as elevated tumorlike projections. The masses are extremely sensitive and bleed very easily. When removed from their attachment a deep ulcer is left in the mucous membrane.

Treatment. The most important procedure in the treatment of a cystitis is to discover the cause and treat it. The inflammatory condition of the bladder will usually take care of itself. Occasionally, however, the cystitis must also be looked after.

Acute cystitis. The patient is put to bed, kept warm, and the fluid intake is greatly increased. The drinking of large quantities of water is very important and serves to make the urine very dilute. A light diet is advocated, and all irritating food and spices are forbidden.

Hot rectal irrigations in the male and hot vaginal douches in the female usually give considerable relief. Bladder irrigations of a warm non-irritating solution such as normal saline or boracic acid together with instillations of a weak silver preparation such as argyrol 10% may be beneficial. Suppositories of opium and belladonna, of each grains one-half, often have a soothing effect, particularly when the symptoms are very distressing.

Alkalis by mouth in the form of soda bicarbonate and potassium citrate are given to render the urine bland, and thus the dysuria may be overcome. These salts are often administered together with tincture of hyoscyamus.

The balsamics are prescribed quite frequently. The most popular are the various preparations of sandalwood oil. The latter drug is given in doses of 5 to 10 minims 2 to 3 times daily.

Of the urinary antiseptics the most popular is urotropin taken in 10 grain doses 3 times daily. It acts best in acid urine and in association with acid sodium phosphate. Other urinary antiseptics are salol, benzoic acid and mythylene blue.

Chronic cystitis. The removal of the predisposing factor is usually sufficient. When this is accomplished the cystitis clears up in a great majority of cases. In the severe and complicated forms one must treat the inflammation of the bladder as well, and one must, therefore, resort to local and general remedies.

Patients are instructed to drink lots of water, keep their bowels regular and avoid irritating foods. Hot sitz baths, hot vaginal douches and rectal irrigations often give considerable relief. Alkalis by mouth are often prescribed. Urinary antiseptics as urotropin, salol, and the balsamics may be given. In aggravated cases opium and belladonna suppositories, one-half to one grain of each, are very helpful.

Local treatment to the bladder in the form of irrigations and instillations is undoubtedly our best aid in treating chronic cystitis. The irrigations must be warm, weak and non-irritating. The best drugs are boracic acid, normal saline and silver nitrate in a solution of 1–10,000. Potassium permanganate in strengths of 1–5000 to 1–10,000 is also a very popular bladder wash.

Instillations are very often used after bladder lavages. The drugs most commonly employed are argyrol 5%–10%, silvol 5%–10%, neo silvol 5%–10%, gomenol 5%–10%.

In the severe and obstinate forms of cystitis the above therapeutic measures are often inadequate. Here surgical treatment may have to be resorted to. Cauterization either suprapubically or through the operating cystoscope is advocated by some surgeons for ulcerative cystitis and leukoplakia. Other authors recommend curettement for incrusted cystitis.

Grant[8] advocates cordotomy for relief of intractable pain in diseases of the bladder. Learmonth[21] advises neurosurgery of the sympathetic and parasympathetic fibers in the treatment of such diseases of the urinary bladder. Caulk[3] advocates the injection of Bulgarian bacilli in all forms of incrusted and alkaline cystitis. These organisms have the power to produce an acidity, thus killing the organisms responsible for the lesion. The treatment carried out by Kearns[18] consists of curettement followed by instillations of 2% acetic acid. Keyes[18] has been using acidophilis milk for many years. Recently Redewell[33] found that leukoplakia, malakoplakia, and incrusted cystitis respond satisfactorily to forced feeding with food rich in vitamines, the use of parathyroid substance and local therapy consisting of fulguration and diathermy.

Pericystitis. This condition results from an inflammation of the loose connecting tissue surrounding the bladder. Retzius[34] in 1856 first published an extensive work on the anatomy of the spaces related to the bladder and prostate. Goldstein and Abeshouse[7] discuss very fully the anatomical relations and particularly the methods of development of perivesical infection.

Etiology. Pericystitis may be due to infection within the bladder caused by stone, foreign body, tumor, diverticulum, prostatitis and stricture of the urethra; or to diseases of adjacent organs such as appendix, intestine, rectum, fallopian tubes, prostate and vasa. Finally it may result from trauma or injuries to the pelvis and pelvic organs.

Symptomatology. Pericystitis may be acute or chronic. In the former type there is severe lower abdominal pain associated with fever, chills and general signs of sepsis. Where suppuration is present one can usually palpate a tender mass just above the pubis. The swelling may be mistaken for a full bladder. The passing of a catheter, however, will immediately decide the issue.

In the chronic pericystitis there are no characteristic symptoms. The picture is that of an ordinary chronic cystitis.

Treatment. Immediate surgical interference is necessary in the acute suppurative pericystitis. If the infection has spread downwards as well, through-and-through drainage from the suprapubic area to the perineum must be performed. In the chronic type, the removal of the cause usually suffices.

TUBERCULOSIS OF THE BLADDER

Tuberculous cystitis is almost always secondary to renal or genital tuberculosis. A few apparently authentic cases of primary vesical tuberculosis have been reported.

Etiology. It may safely be said that 85% to 90% of cases of bladder tuberculosis are secondary to similar lesions in the kidney; the remaining 10% to 15% result from a tuberculous infection of the prostate, seminal vesicles and epididymes.

The disease usually occurs in young people between the ages of 20 and 40 years. No age is exempt, however. Judd and Scholl in a series of 863 cases found that 85% of them were between the ages of 20 and 50 years.

Regarding the relative frequency of vesical tuberculosis in the male and female it has been found that males are affected more often than females. This can be partially explained by the fact that genital tuberculosis is common in the male and rare in the female.

Pathology. *Gross.* In a renal lesion the trigone and the corresponding ureteral orifice are first involved. On the other hand, if the primary focus is in the genital tract, then the first evidence of invasion is found in the vesical neck.

Hallé and Motz[11] have made a very extensive study of vesical tuberculosis and have described the various stages of development. In an early kidney lesion the trigone and the ureteral orifice of the affected side are reddened and swollen. Small greyish tubercles soon appear and are particularly seen near and about the ureteral opening. As the disease progresses the tubercles coalesce, caseate, break down and form superficial ulcerations. Now, one may see large irregular ulcers surrounded by tubercles. The ulcer is shaggy and has a dirty greyish base. There is always an area of hyperæmia about it. Late in the disease all the coats of the bladder become infiltrated with connective tissue. This results in a markedly thickened, greatly contracted and non-dilatable bladder. A pericystitis usually complicates the picture.

The affected ureteral orifice also undergoes great change. At first it is gaping and ulcerated but later it becomes scarred and retracted. Occasionally in late vesical tuberculosis one sees a large scarred and retracted orifice — the so-called golf hole ureteral orifice.

Histology. The histological picture is identical with that of tubercle formation in any other organ of the body. There are the areas of caseation, and the presence of giant lymphoid and epithelioid cells. All the layers of the bladder are infiltrated with connective tissue cells.

Symptomatology. The symptoms of vesical tuberculosis are slow in their onset and the history usually extends over a long period of years.

1. *Frequency of urination.* Ordinarily, frequency is the first symptom complained of. Early in the disease it is of a mild character and patient notices that he or she has to get up once or twice during the night to void. As the disease progresses the symptoms become more severe and in very advanced cases there is an almost constant desire to urinate.

2. *Dysuria.* Painful urination is always associated with frequency. It may be terminal or occur during the act of urination. Late in the disease the pain is most distressing and makes the patient very miserable.

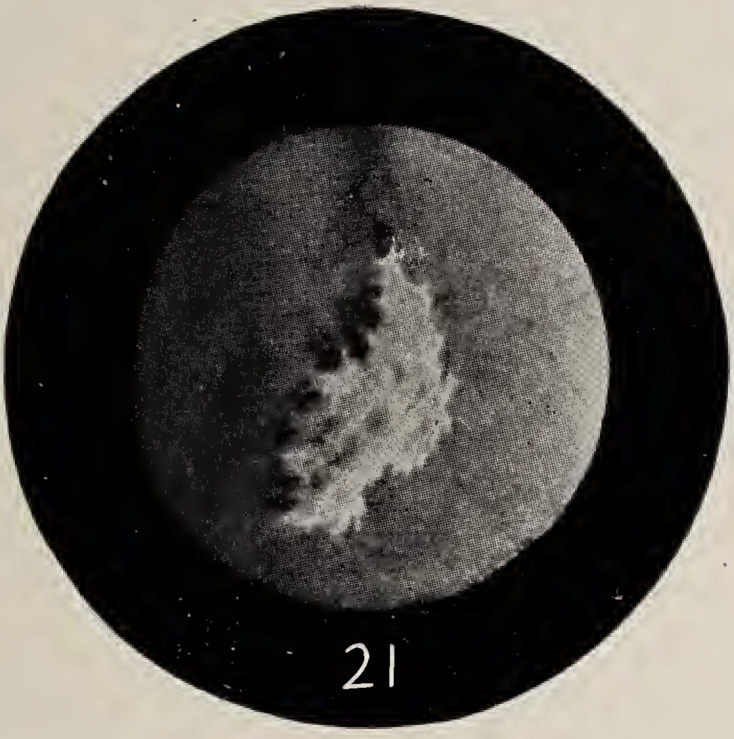
3. *Hæmaturia.* This symptom is present at one time or another during the course of the disease. It may be profuse or very slight and may occur during or towards the end of the act of urination. Very often the first symptom complained of is blood in the urine. Usually it is not influenced by rest or motion, for a profuse hæmorrhage may occur while patient is lying quietly in bed.

4. *Incontinence and dribbling.* These symptoms are occasionally seen. They are usually present late in the disease when the bladder is markedly contracted.

5. *Sensitiveness of the bladder.* A very outstanding and characteristic point in vesical tuberculosis is the extreme sensitiveness of the bladder. Even the most gentle instrumentation is almost unbearable. The bladder is greatly contracted and its capacity very small. Distention, therefore, causes extreme discomfort. This is greatly emphasized during a cystoscopic examination.

6. *Systemic Symptoms.* These are conspicuous by their absence. Very often the patient appears in fairly good health. The appetite is good and the weight steady. If there is no pulmonary or glandular tuberculosis the body temperature is normal.

7. *Urine.* An analysis of tuberculous urine will reveal a low specific gravity, an acid reaction, microscopic or macroscopic blood and few or many pus cells. A smear made of the urine will show acid fast bacilli in a large majority of cases.



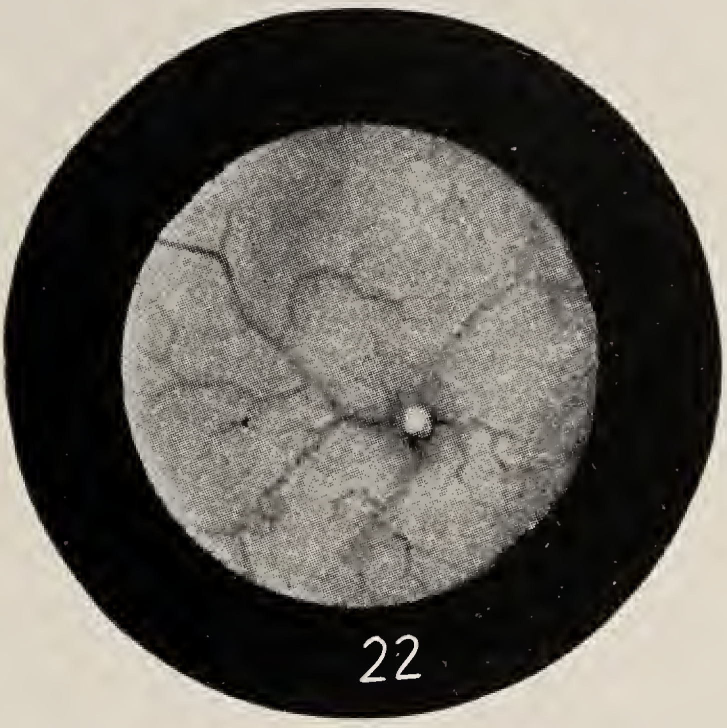


Fig. 21. Incrusted cystitis. Note the incrustation which is elevated and resembles somewhat a villous growth (Mercier).

Fig. 22. A tubercle in a tuberculous cystitis. The bladder mucosa is markedly inflamed. Note the area of hyperæmia about the tubercle (Mercier).

Diagnosis. It must be emphasized that any cystitis which resists ordinary every-day treatment should be investigated. One's suspicion is greatly enhanced if a patient who is a young adult gives a history of frequency of urination over a long period of time associated with dysuria and some hæmaturia. Our greatest aids, however, in making a final diagnosis are the presence of tubercle bacilli in the urine, the guinea pig innoculation and finally the cystoscopic examination.

The diagnosis of a tuberculous bladder means a similar lesion in one or both kidneys or in the genital tract. It is imperative, therefore, to find the initial focus.

Cystoscopic appearance. The bladder is always hypersensitive and any distention of the viscus causes considerable discomfort. At times the bladder capacity is less than one ounce. In very advanced cases cystoscopy may even be impossible to perform.

The early findings of a tuberculous cystitis when secondary to unilateral renal tuberculosis, are redness and swelling about the trigone and the corresponding ureteral orifice. Tubercles soon make their appearance and are seen near and about the ureteral opening. (Fig. 22.) As the disease progresses the tubercles break down, caseate and form ulcerations. One may now see large irregular ulcers surrounded by tubercles and an area of hyperæmia. (Fig. 23.) In bilateral renal tuberculosis both ureteral orifices are thus affected. Late in the disease when the bladder undergoes sclerosis and contraction the ureteral orifice appears scarred, retracted and irregular. (Fig. 24.) It is often spoken of as the golf-hole ureteral opening.

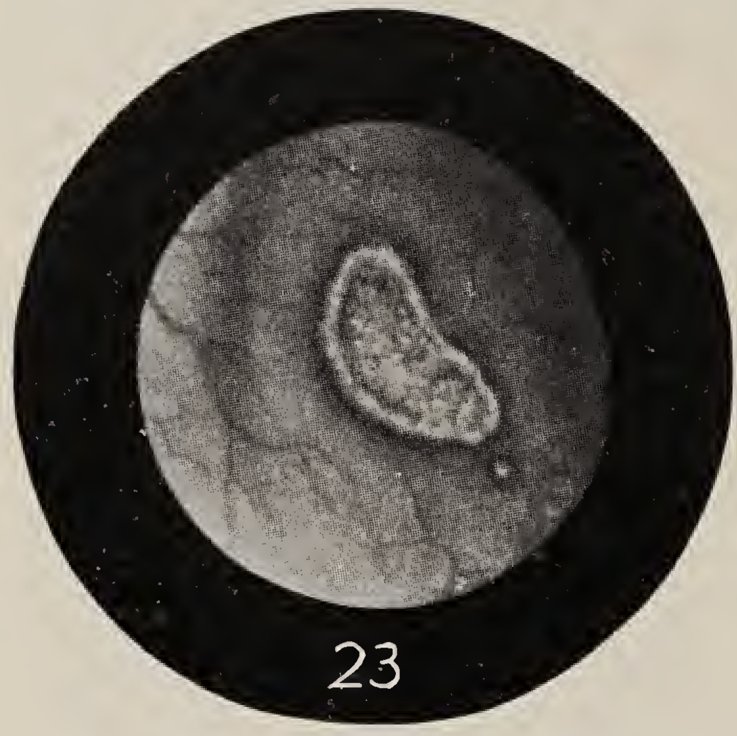


Fig. 23. Cystoscopic appearance of a tuberculous ulcer. Note its shaggy appearance, the dirty base and the area of hyperæmia about it (Mercier).

In genital tuberculosis the changes are first observed about the vesical neck. Later there is usually present renal tuberculosis as well, and the picture is that of an extensive tuberculosis of the bladder.

Prognosis. Vesical tuberculosis is usually secondary to unilateral renal tuberculosis. If the diseased kidney is removed early the bladder will nearly always take care of itself. In advanced renal tuberculosis where there is marked ulceration and the destruction of the bladder wall the prognosis is not good. Here there is almost irreparable damage and as a result of it the patient will suffer considerably.

The prognosis is bad for cure if there is bilateral renal tuberculosis or extensive genital tuberculosis. These patients if properly taken care of will enjoy a considerable amount of comfort.

In mild genital tuberculosis the prognosis is good.

Treatment. The outstanding point in the treatment of vesical tuberculosis is to find the cause and remove it. This must be accomplished before there is extensive destruction and ulceration of the bladder wall. If there is present a unilateral renal tuberculosis a cure will result after nephrectomy. The bladder lesion will also heal if a mild genital lesion is properly treated. These surgical procedures are always supplemented by hygienic measures. The patient is given good nourishing food, tonics, lots of fresh air, sunshine, ultra-violet rays and rest.

Surgical interference is out of the question in bilateral renal tuberculosis, massive genital tuberculosis, and in those cases that do not respond favorably after operation. The treatment here consists of systemic and local therapy.

Systemic. The patients are given fresh air, sunshine, good food, tonics and rest. Some advocate sanatorium treatment. Some patients are also given tuberculin therapy.

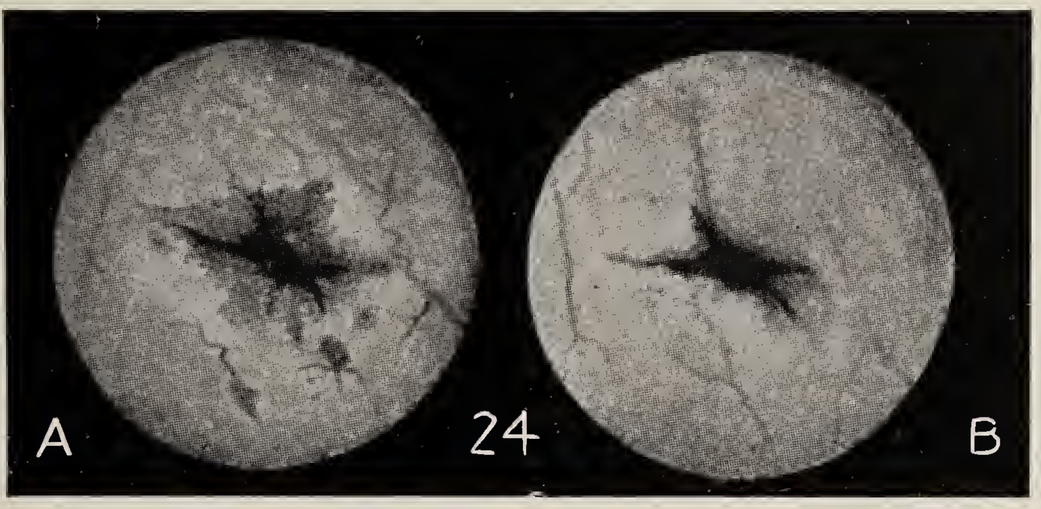


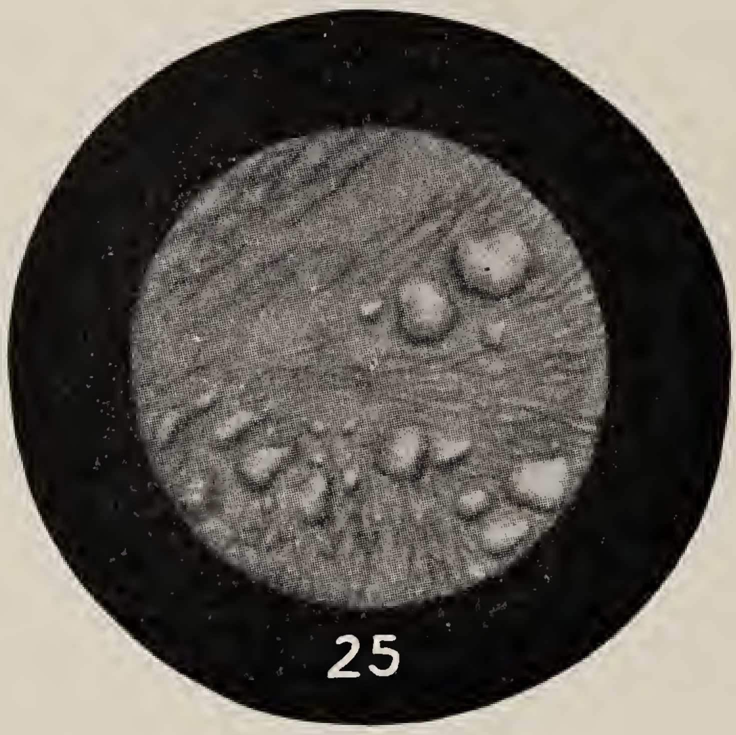
FIG. 24. The appearance of a ureteral orifice in renal tuberculosis. (*a*) Note the redness, swelling and ulceration. (*b*) Same ureteral orifice six weeks after nephrectomy (Barringer and Keyes).

Local treatment. If the symptoms are not very troublesome no local therapy is necessary. If, however, there is considerable discomfort instillations are given and only with the greatest care. Irrigations are never to be used because of the discomfort that results from the distention of the bladder.

Gomenol in strengths of 5%, 10% and 20% solutions is a favorite mixture today, and often is very comforting to the patient. In extreme cases carbolic acid in strengths of 1–200 to 1–50 may be used. Keyes is a great advocate of this procedure. Normand[26] has reported excellent results by employing nascent iodine. In very stubborn tuberculous lesions the high frequency current may be used with, at times, good results. In very extreme incurable cases some surgeons transplant the ureters. Papin[29], in a very extensive treatise, advocates iliac ureterostomy. He reports excellent results.

SYPHILIS OF THE BLADDER

This condition is very uncommon and there are only a small number of authentic cases reported. The first cystoscopic diagnosis of vesical syphilis is generally credited to Matzenhauer.[24] In 1901 he described small elevated papillomatous projections in the neighbourhood of the ureteral orifice which proved to be syphilitic. Since then other observers have reported similar lesions. The majority of cases on record are those of tertiary or gummatous processes, although a small number of rather indefinite secondary syphilis of the bladder have been described.



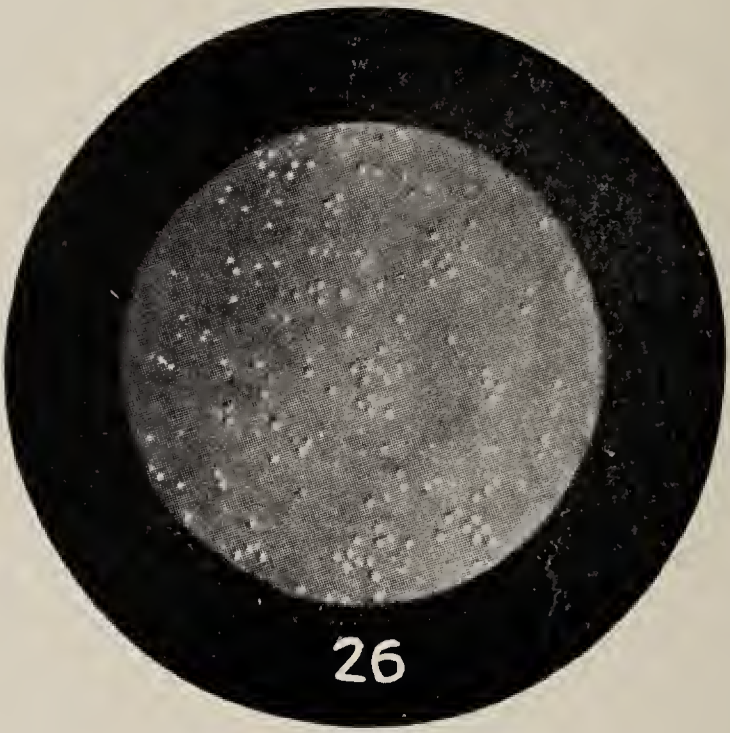


Fig. 25. Syphilis of the bladder. Note the many sharply outlined gummatous lesions, some of which are ulcerated. The bladder mucosa is markedly inflamed (Picot and Mercier).

Fig. 26. Cystoscopic picture of Bilharziosis of the bladder. Note the many discrete whitish granules scattered throughout a chronically inflamed bladder (Mercier).

In secondary lues the lesions are similar to those of the skin or mucous membranes that are easily accessible to the naked eye. There may be generalized or local reddening, ulcerations, nodules, or tiny vesicles. None of these findings, however, are pathognomonic of the disease.

The tertiary or gummatous lesions also resemble similar conditions elsewhere in the body. They are sharply outlined, often ulcerated and are always surrounded by a zone of bluish red discoloration. (Figs. 25, 26.) Very often there is observed bullous œdema about and near the granuloma. The cystoscopic picture, however, is positively not pathognomonic of the disease. Before making a diagnosis of syphilis of the bladder the

Wassermann should be positive and the lesions should respond to antiluetic therapy.

Symptomatology. The symptoms are the same as in chronic cystitis, namely, the frequency, urgency, dysuria and hæmaturia. These symptoms do not present any features that are characteristic of the disease.

Treatment. This consists of antiluetic therapy.

Elusive ulcer. (Hunner). This lesion was first described by Hunner[14] in 1914. Since then there has been considerable discussion and literature on the subject. In the early period of the study this lesion was thought to be a local process. Since then, however, there has been a tendency to regard the lesion as a part of a generalized chronic inflammation involving the entire thickness of the bladder. Young[37] employs the term submucous or interstitial cystitis to describe the condition and is of the opinion that the ulcerations are not characteristic of the disease but are due to a previous distention of the bladder. Eisendrath and Rolnick[5] agree with Young. We personally agree with the view held that the lesion is just a part of a generalized chronic inflammation in which there is a fibrosis of the submucosa and muscle coats.

Etiology. These lesions are far more common in women than in men and may occur at any age. Hunner believes that focal infection such as teeth, tonsils and sinuses plays a great part as an etiological factor.

Pathology. The pathological picture is that of a chronic cystitis in which there is involvement of the submucosa and muscle coats by dense fibrosis. As a result of the marked fibrosis the bladder wall is greatly thickened and its capacity is markedly diminished. The lesion often extends through the bladder wall and involves the prevesical tissues. The mucosa usually shows some redness, swelling and linear ulcerations, chiefly in the bladder vault and in the upper lateral and posterior walls. In many areas the blood vessels are numerous and prominent. There are both polymorphonuclear and round cell infiltration.

Symptomatology. The symptoms are usually quite marked but their severity is out of proportion to the clinical findings. The patients suffer with marked frequency, urgency and painful urination. Occasionally there is present stabbing-like pain in the lower abdomen radiating downwards to the urethra.

The urinary findings are very often normal; occasionally red blood cells are found in the urine.

Diagnosis. The diagnosis is usually made by the cystoscope. The bladder capacity is greatly diminished and even slight distention causes a strong and painful desire to void. The patients are also extremely sensitive to any instrumentation. The bladder mucosa is reddened and œdematous and on the vault and on the lateral and posterior walls of the bladder are seen one or many linear ulcerations. These lesions may be small or large; clean or covered with fibrin or phosphatic material. There is usually considerable œdema about each ulcer. Occasionally there may be small areas of punctate hæmorrhage on the mucosa. These lesions are very sensitive and bleed easily to touch or to overdistention of the bladder. They have a tendency to heal quickly only to reappear in another portion of the bladder.

Treatment. The treatment of this condition as advocated by Hunner[15] consists of removing all foci of infection followed by instillations of one ounce of silver nitrate in the strength of 1–500 twice weekly. He considers this procedure one of the simplest methods of effective treatment. If the results are not satisfactory he[15] prefers fulguration under complete narcosis. Hunner[17] has also performed resection of the involved portion of the bladder. He has found, however, that 42% of them have had a recurrence. Peterson and Hager[32] recommend transurethral electrocoagulation, overdistention of the bladder or a combination of the two. They report excellent results.

Simple ulcer. This lesion was first described by Fenwick.[6] Its etiology is not understood. Some consider pre-existing infection, toxic influences and trophic disturbances as etiological factors. Keyes[19] considers this ulcer as an accentuation of the elusive ulcer. Braasch[2] believes that the simple ulcer primarily involves the mucosa while the elusive ulcer involves predominantly the submucosa.

Pathology. The bladder mucosa may be clear or may be chronically inflamed. The ulcer is usually situated just behind the trigone, occasionally it is situated in the vault. The lesion is clear-cut, regularly outlined and surrounded by an area of hyperæmia.

Symptomatology. Hæmaturia is the outstanding symptom. Very often there are present the usual symptoms of a chronic cystitis.

Treatment. Conservative treatment should be advocated. Paschkis[30] reports good results with oil treatment of the bladder (callargol, gomenol). For resistant cases electrocoagulation is recommended.

Bilharziosis. This disease is extremely rare in this country. It is most frequently found in Africa and Egypt. It is caused by the Schistosomum hæmatobium first described by Bilharz. The pathology is that of a chronic cystitis with ulceration, granulation and epithelial proliferation. (Fig. 10.)

Symptomatology. Hæmaturia is the first symptom. Later there may be the other symptoms of a chronic cystitis.

Diagnosis. The urine always has the ova which when present are easily recognized.

Treatment. This consists of the intravenous injections of antimony tartrate which is a specific for the disease.

Other parasitic infections of the bladder caused by the Anguillula Aceti and the Eustrongylus gigas have been reported.

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FOREIGN BODIES IN BLADDER INCLUDING VESICAL CALCULI

Calculi are by far the most common foreign bodies to be met with in the urinary bladder. Parts of instruments, catheters, filiform bougies, lithotrites, etc., are less frequently found than formerly. Foreign objects such as speicules of bone, bullets, particles of clothing, etc., occasionally gain access as a result of wounds, and exceptionally surgical sponges and silk sutures left in surrounding tissues at surgical operations may ulcerate through the bladder wall. Likewise dermoid cysts have been known to evacuate their contents into the bladder, or sloughs following operations may remain and become the seat of calcareous deposit.

Foreign bodies in the bladder. Foreign bodies arrive in the bladder by two routes: (1) Those introduced through the urethra.

(2) Those which reach the bladder by perforation of the overlying tissues, as in wounds or during surgical operations not upon the bladder itself.

Etiology. Various instruments have been introduced into the bladder by the urethra — pencils, crayons, hairpins, screw drivers, pins, catheters, filiform bougies and practically every conceivable substance. These occur almost exclusively in women, usually as a result of accidental perversions of the sexual act or in the insane. While men are more prone to this perversion these objects are found more often in the female

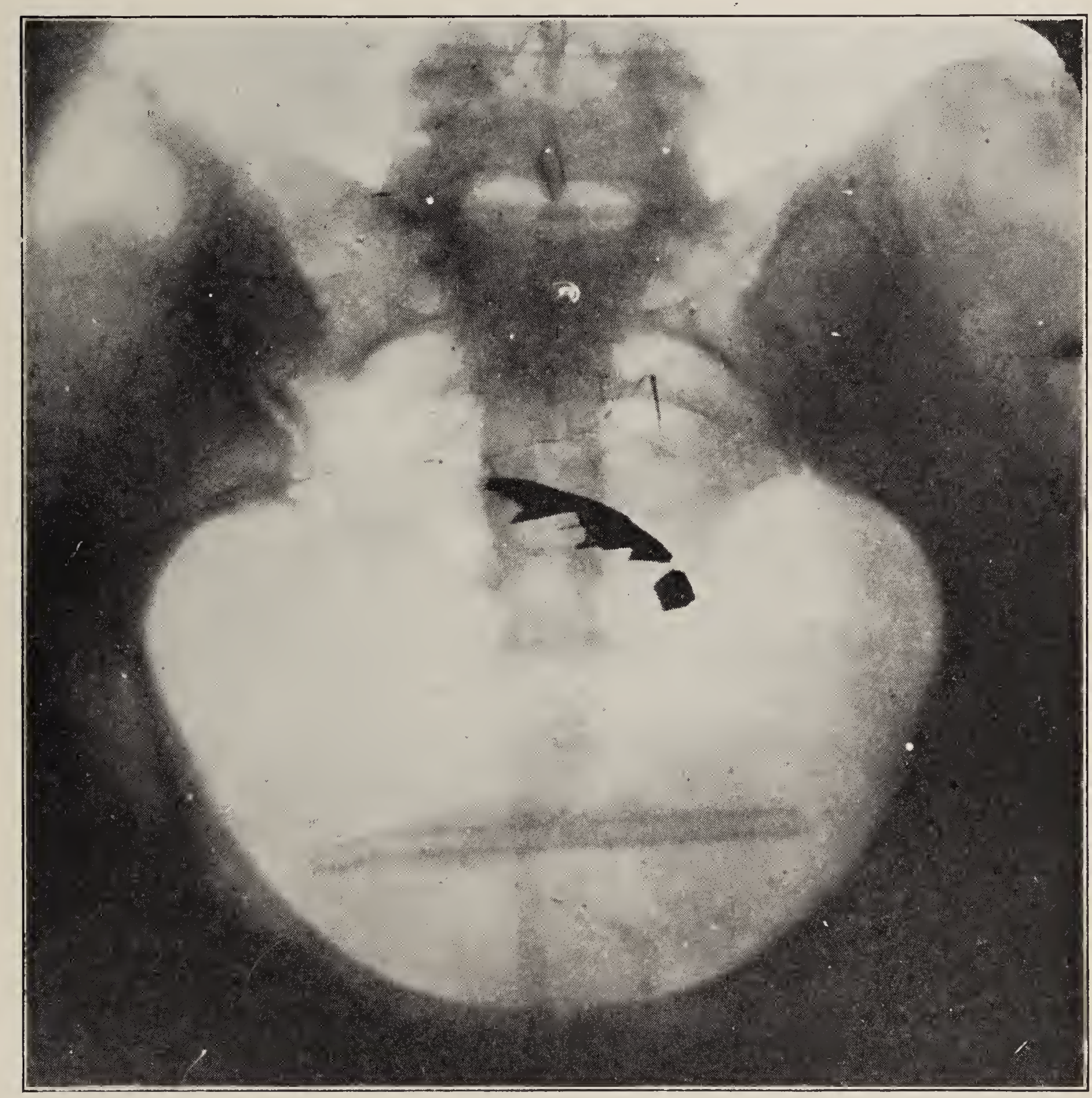

FIG. 27. Skiagraph of broken glass catheter in bladder of woman who had been catheterized at labor three months previously (Author's case).

bladder, doubtless due to the shorter urethra and the greater readiness with which an object can pass into the bladder.

Symptoms. Cystitis is sure to follow the introduction of a foreign body into the bladder through the urethra. Usually the symptoms are frequency, difficult and painful urination, sometimes stoppage of the stream and often hæmaturia. If the foreign body has been in the bladder for some time the symptoms may be intermittent.

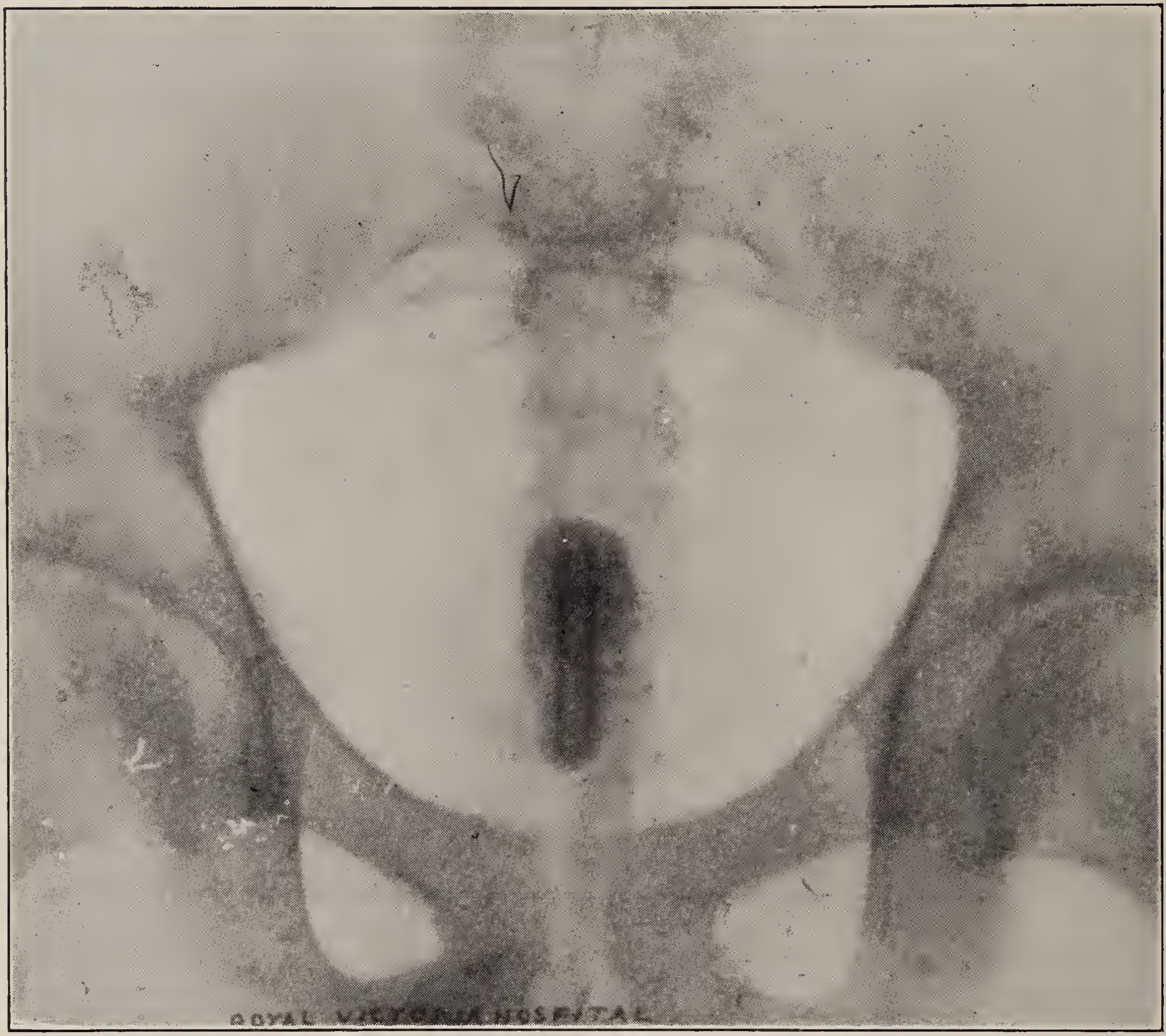

FIG. 28. Skiagraph of foreign body (rubber tubing) in bladder of young lad of eighteen years (Author's case).

Diagnosis. The history usually gives no clue as to the true state of affairs. The diagnosis is made by the cystoscope and the X-ray.

Treatment. There are two methods of removing foreign bodies from the bladder: (1) Through the urethra. (2) By suprapubic cystotomy.

Removal of foreign bodies through the urethra is feasible only where the foreign body is of such a size as to readily pass through the urethra. In this way catheters, filiform bougies, pieces of gum, straws, etc., may be removed by means of the cystoscope or the lithotrite. Because of the shortness of the female urethra and its dilatability such objects as glass catheters, button hooks, bodkins and small screw drivers have been removed by the author either by the cystoscope or, failing that, by manipulation with the finger through the urethra and vaginal palpation. Removal of a foreign body too large to pass through the urethra or one likely to cause trauma to the urethra should be removed by suprapubic cystotomy.

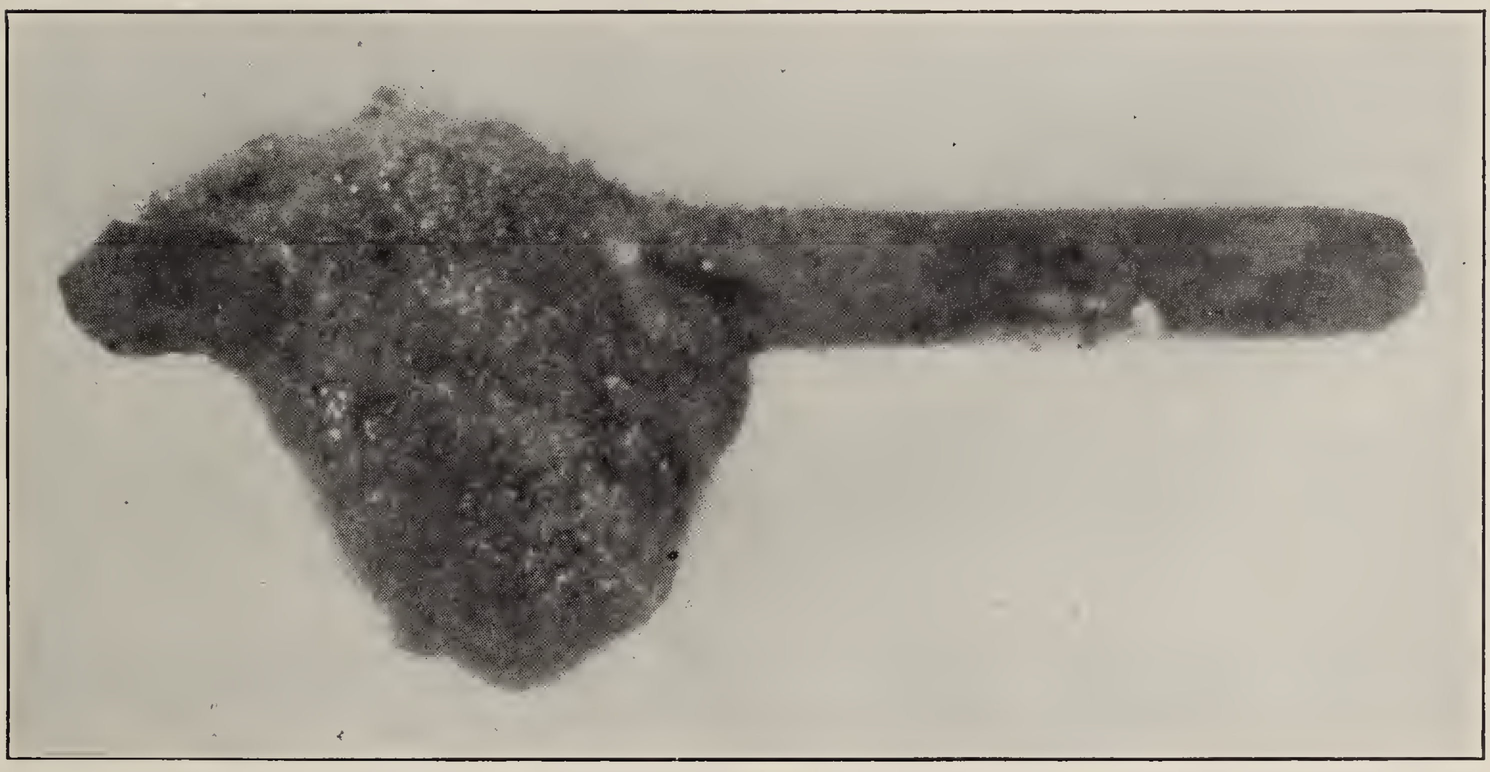

FIG. 29. Photograph of lead pencil encrusted with urinary salts removed by cystotomy from bladder of young woman (Author's case).

Stone in the bladder. Calculi are said to consist of precipitated urinary salts, epithelium, mucus and various other exudates about a nucleus which must be colloidal material. This commonly accepted theory has lately been put much in doubt. For Shattuck has declared that in order that crystallization of the various urinary salts be initiated the urine must be supersaturated, and that the presence of shed epithelium, mucus, blood clot, bacterial colonies, etc., is not necessary as a starting point for such to take place.

Keyser further states that "the formation of calculi is due to a disturbance of the normal colloidal mechanism of the urine, either in holding water-insoluble materials in solution, or in precipitating crystals as isolated entities". And the experiments of Rosenow and Meisser suggest that the colloidal disturbance may be due to bacterial invasion either from a distant focus or from a local disease in the urinary tract.

Stone formation, then, is likely to come about when the urine is supersaturated with one or other of the various urinary salts in the presence of some disturbance in the colloidal mechanism of the urine; and which disturbance may occur, due to some distant or local disease.

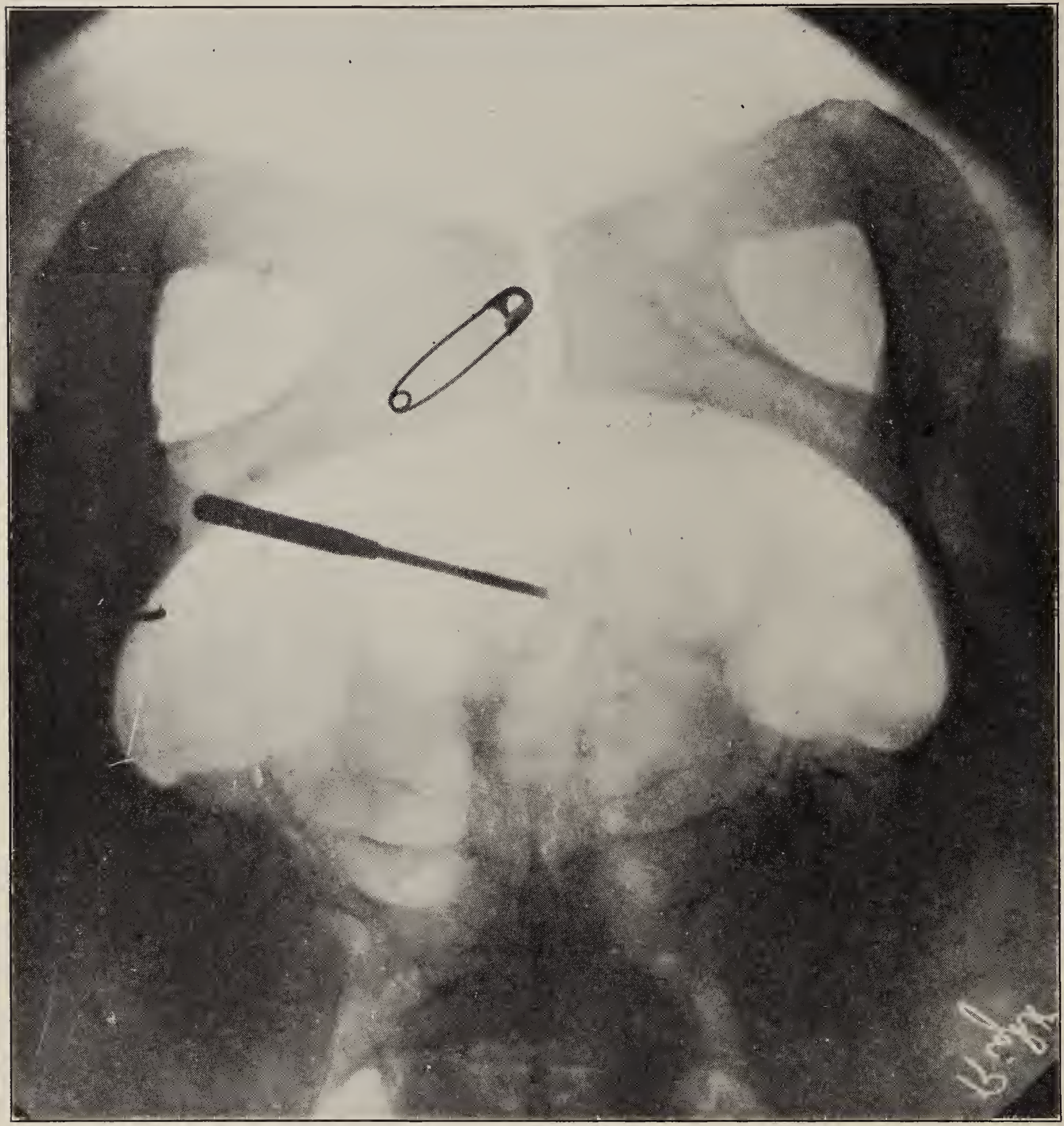

FIG. 30. Skiagraph of foreign body (screw driver used in sewing machines) in bladder of woman thirty-six years old. Removed from bladder by finger in urethra and manipulation per vaginum (Author's case).

Whatever the nucleus may be, once it is initiated crystalline deposition begins about it and then may proceed more or less rapidly.

Vesical calculi may begin in the kidney and descend to the bladder and this type usually form in an acid urine; or they may originate in the bladder, usually in an alkaline urine. Stones may have layers of acid

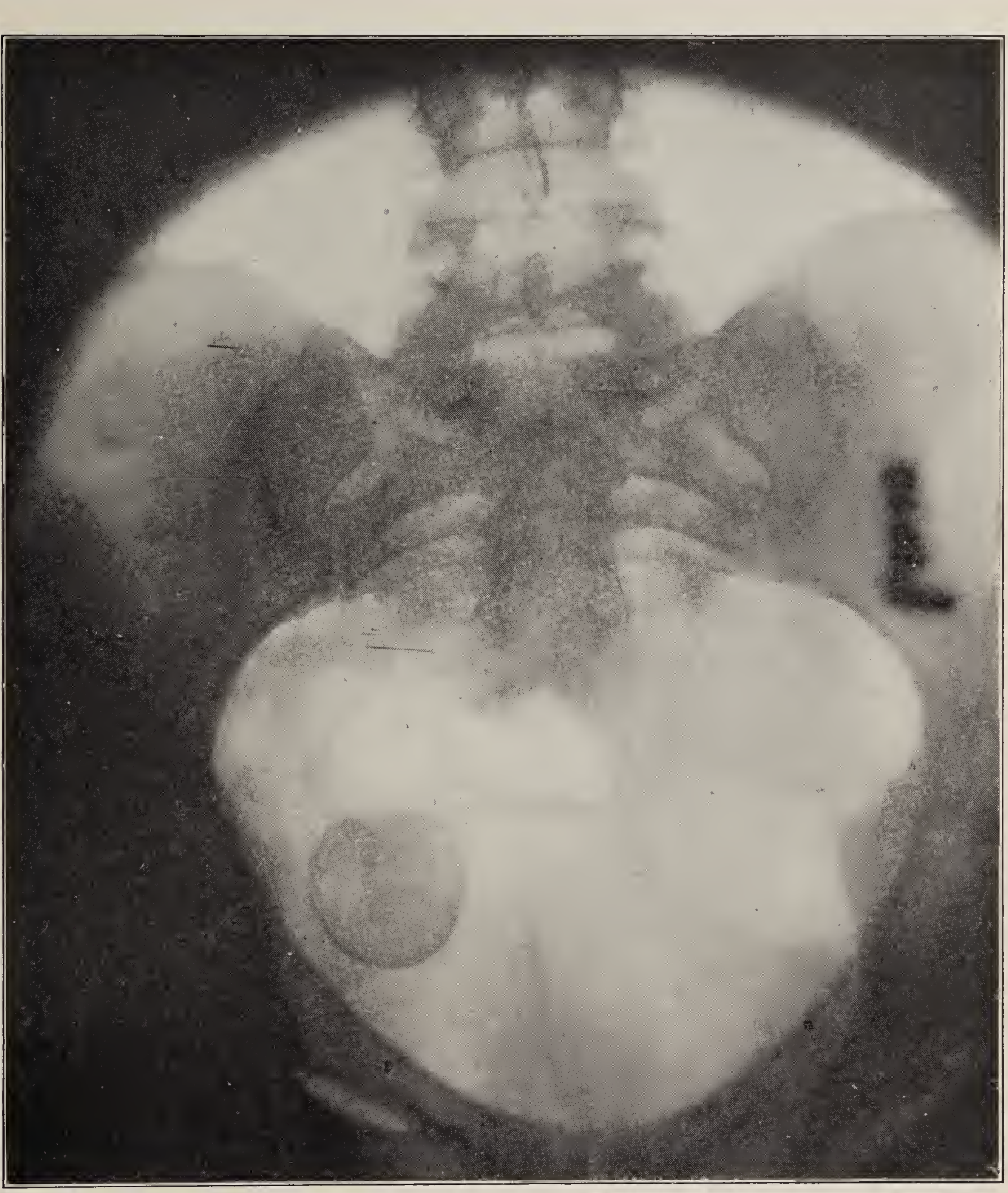

Fig. 31. Skiagraph of foreign body in bladder (surgical sponge) of woman eight months after gynæcological operation (Author's case).

salts overlaid by layers of alkaline salts due to the varying reaction of the bladder urine. Thus, there are concentric rings of different salts in the same stone.

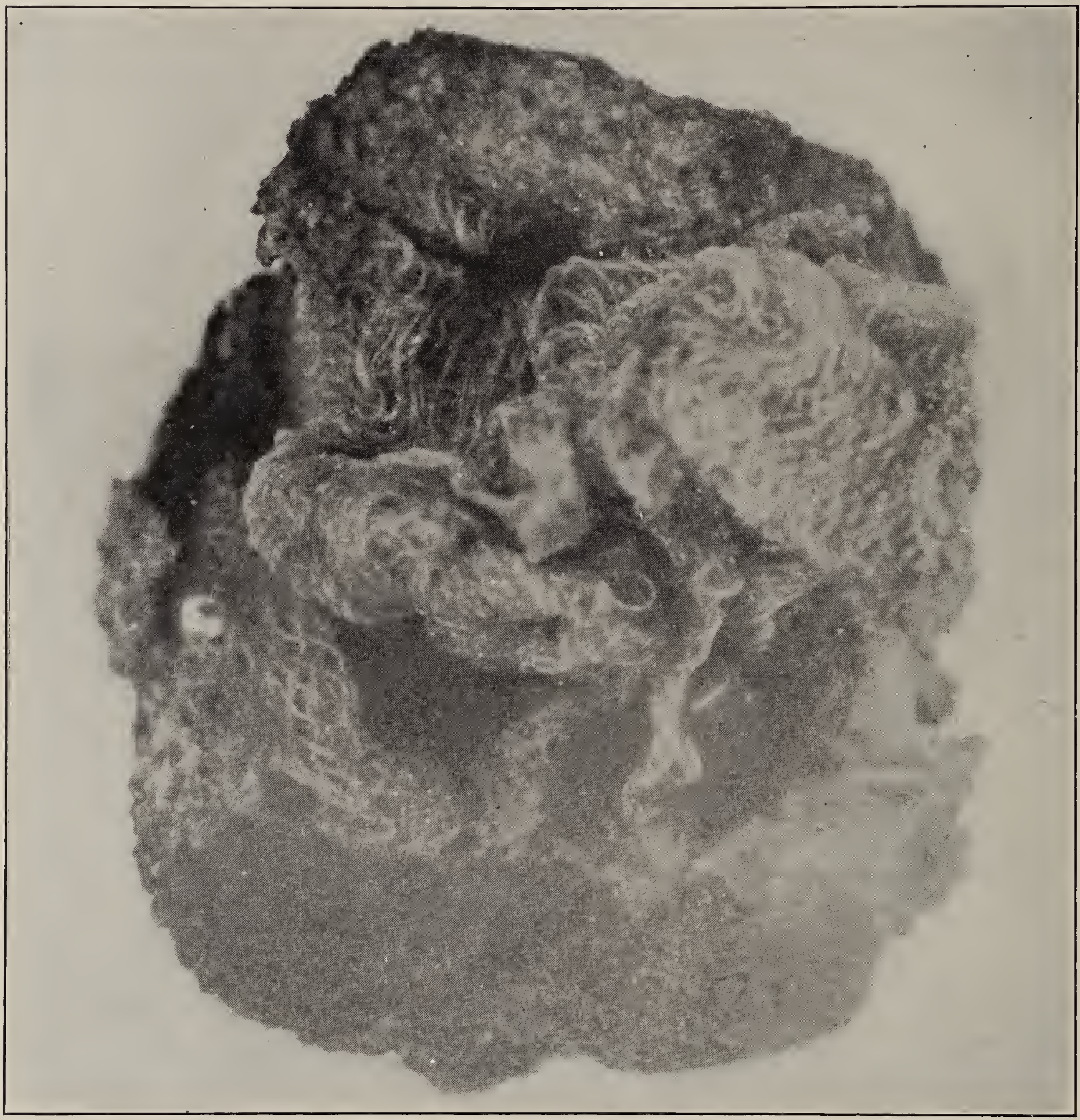

FIG. 32. Photograph of sponge removed from bladder of patient mentioned in Fig. 31 (Author's case).

Any mechanical factor causing retention of urine in the bladder will favor the formation of stone. Thus, such conditions as contracted vesical neck, prostatism, sacculation of the bladder, urethral obstruction, diverticulum of the bladder, are complicated by stone.

Watson and Cunningham (quoted by Lower) classify urinary stones according to their principal urinary salts.

(1) Uric acid and acid urates.

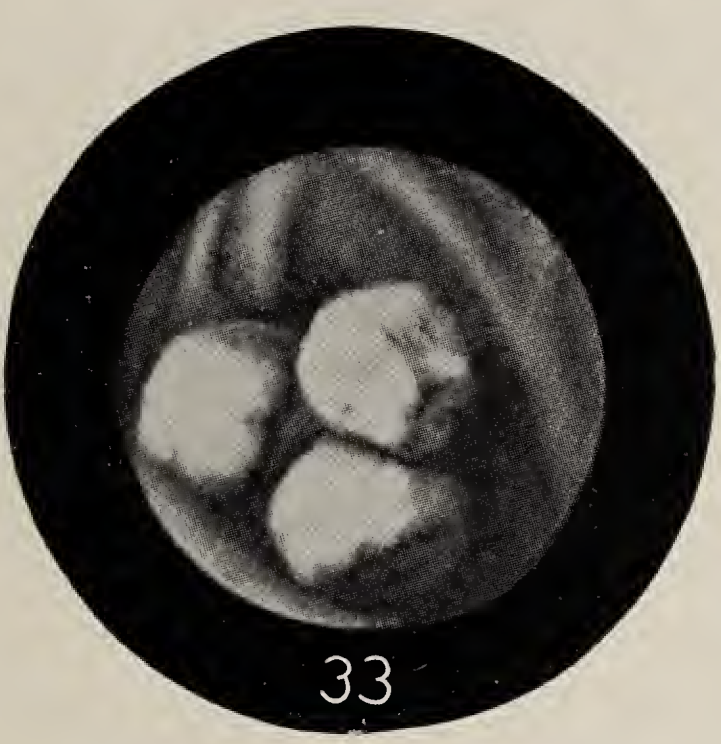

Fig. 33. Facetted phosphatic vesical calculi (Mercier).

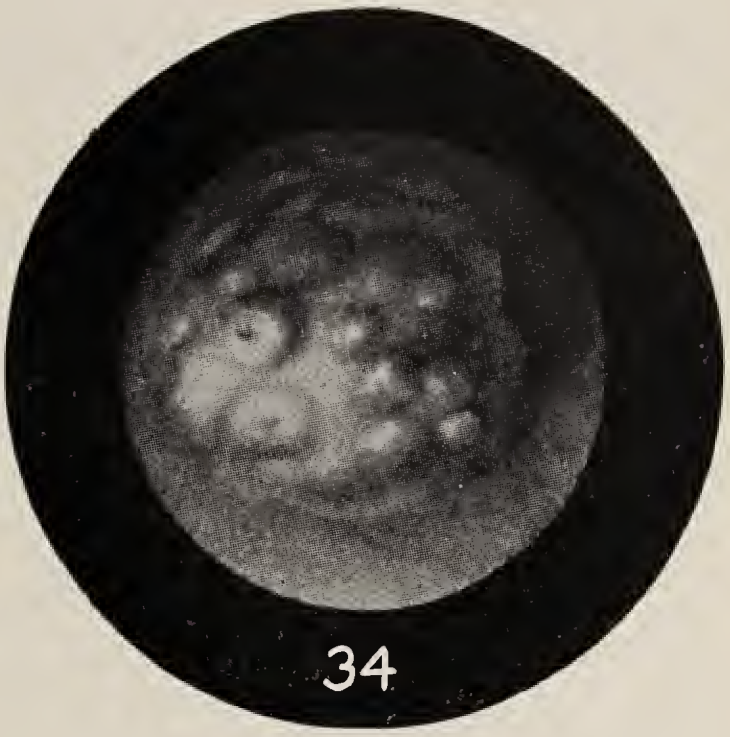

Fig. 34. Uric acid vesical calculus (Mercier).

(2) Calcium oxalate.

(3) Phosphatic.

(4) Cystin.

(5) Rare calculi of xanthin, urostealith, indigo.

Stones are found more frequently in men than in women. The latter are freer of calculi, undoubtedly because the urethra is shorter, more easily dilated and the anatomy so arranged that there is less obstruction at the vesical outlet.

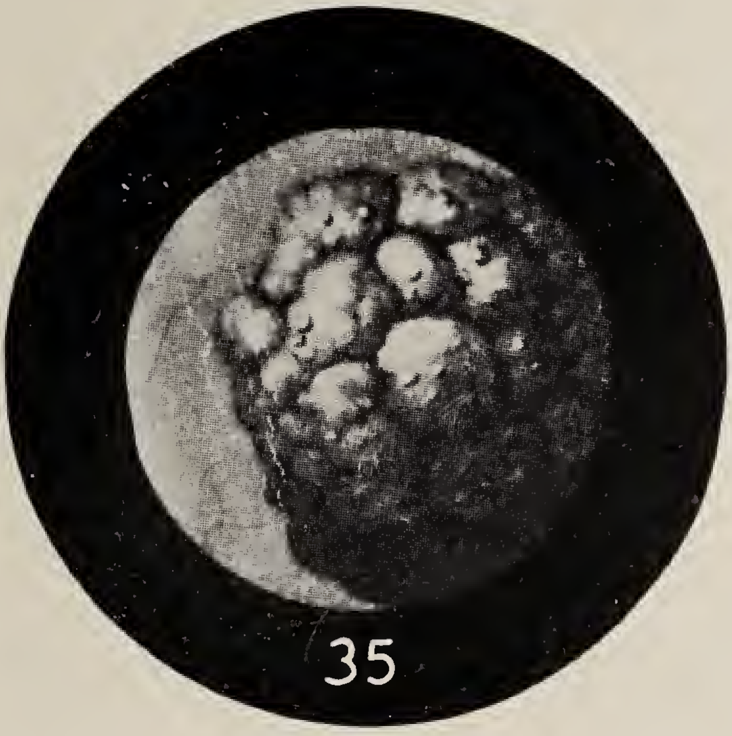

Fig. 35. Oxalic acid vesical calculus (Mercier).

In India, China and certain parts of Hungary, stones are notoriously common, probably due to habits to eating and drinking as well as climate and water conditions. There is undoubtedly a hereditary diathesis in certain families.

Shape. The usual shape of calculi is round or ovoid when occurring singly, but when multiple they influence one another's shape and their contiguous surfaces may be faceted and smooth. Not so with single stones; their surface may be smooth, may be slightly roughened or entirely covered with spicules as in the case of the mulberry calculus. The stone may lie free in the bladder, may rest in a pocket behind an enlarged prostate, or may be entirely within a diverticulum which failed to drain; such a stone is said to be encysted.

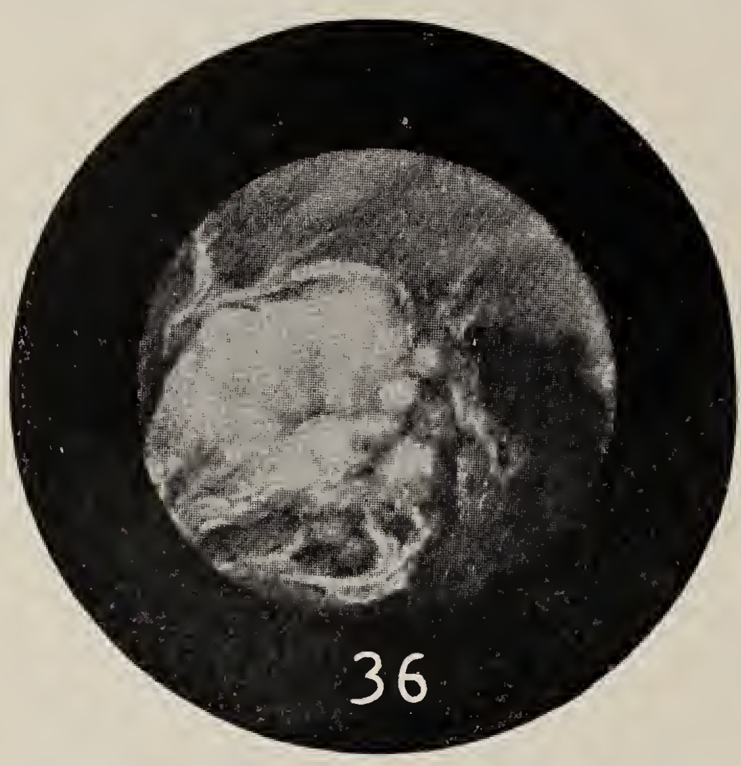

Fig. 36. Phosphatic vesical calculus covered with filaments (Mercier).

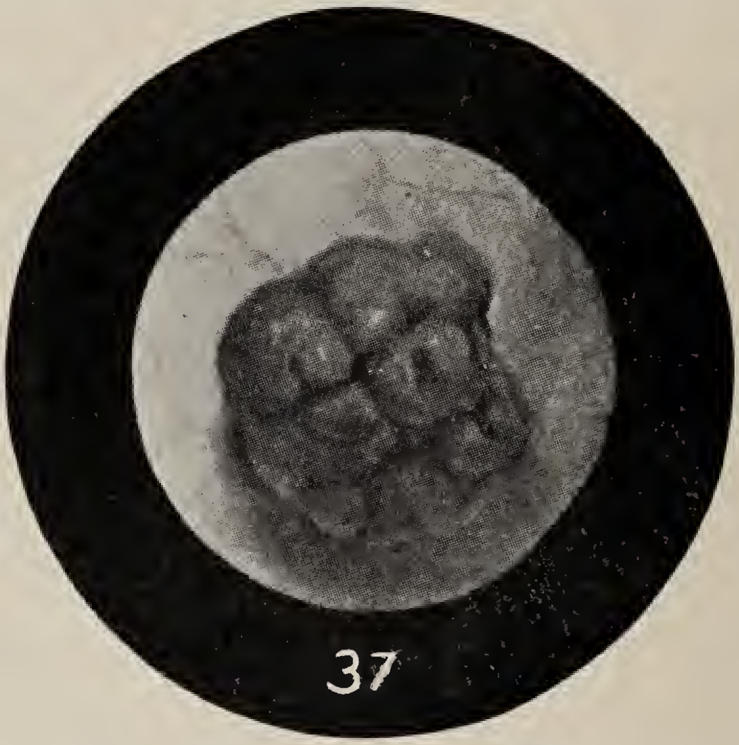

Fig. 37. Blood clot resembling vesical calculus (Mercier).

Size. One rarely sees large stones in this country; Smith reports one weighing 24½ ounces (735 gm.) and Banker one 25 ounces (750 gm.) The writer has in his collection one weighing 42 ounces. This patient survived operation and is alive today.

Spontaneous fracture, an exceedingly rare phenomenon, is said to occur as a result of prolonged dilution weakening the colloidal framework. This is the basis of advertising for exponents of various mineral waters. However, experience proves that they are of no value and even if fracture occurs the patient is no better off, as the bladder is full of fragments, some of which are certain to remain as nuclei for new calculi.

Pathology. Inasmuch as vesical calculi are essentially secondary to chronic inflammation of the bladder, retention, etc., the pathological changes are those of the underlying condition and are aggravated by the presence of the stone. Thus, an inflammatory process is further aggravated, difficulty in emptying the bladder is further increased. A very striking and constant finding is a marked impairment of kidney function in all cases of vesical calculi.

Symptomatology. The usual history is that of frequent painful micturition with hæmaturia and possibly sudden blocking of the stream.

The frequency and pain are usually most marked during the day and the patient has an aversion for riding on rough roads, moving quickly or doing anything which is likely to cause the stone to move. Small irregular stones cause the most intense agony; they may drop into the vesical neck and cause intense spasm and marked difficulty in voiding or sudden blocking of the stream, which may be relieved when the patient lies down exhausted and the stone falls away from the bladder neck. Hæmaturia is

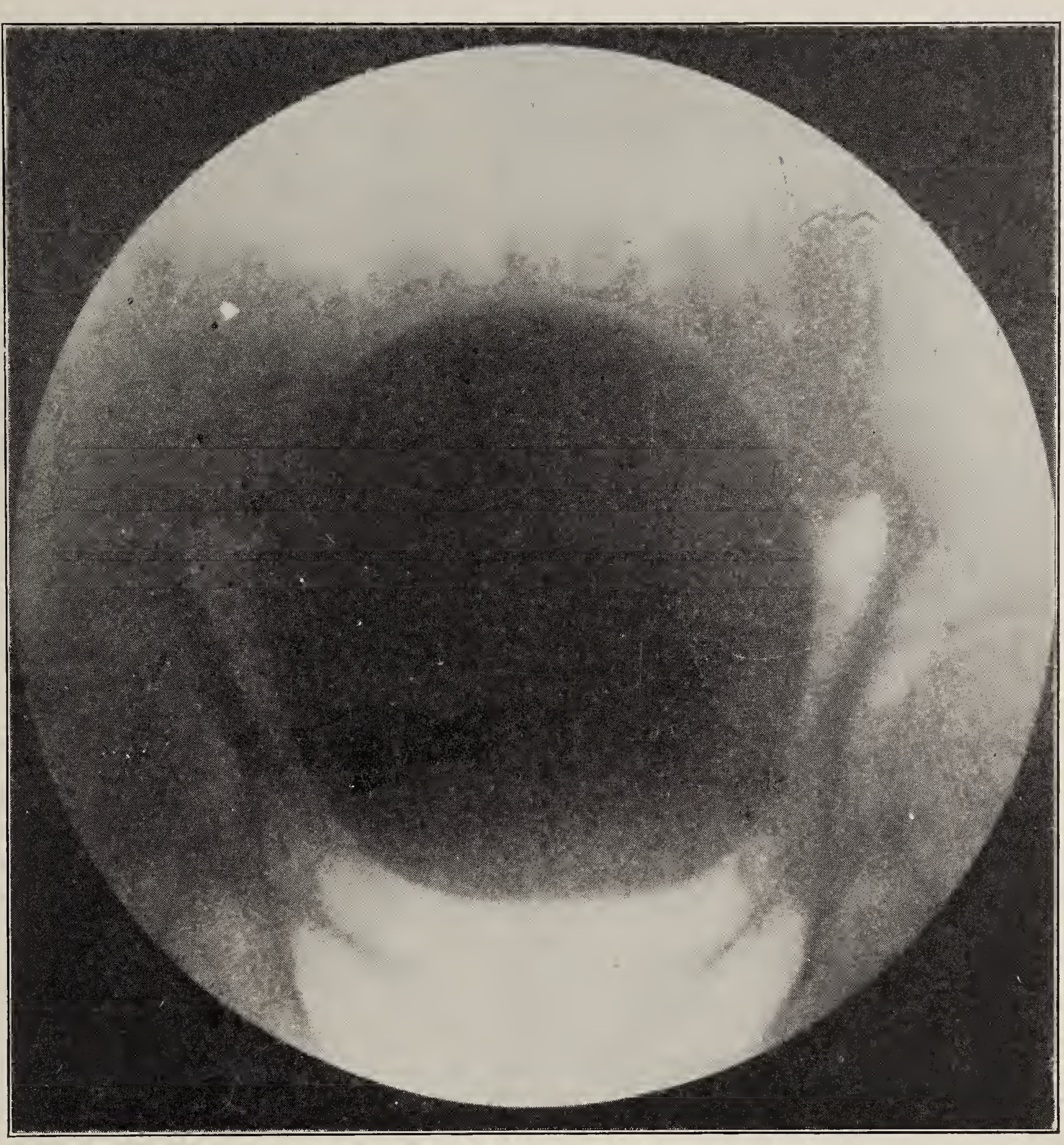

Fig. 38. Skiagraph showing large vesical calculus. Removed from man aged fifty-two in 1918. Weight 42 ounces. Stone impacted in pelvic bones. Urates predominating salts. Patient alive and well fourteen years after removal (Author's case).

the result of trauma and may be precipitated by violent exercise or when for other reason the mucous membrane is injured. The hæmaturia is very variable, it may be only slight and appear as a few drops at the end of micturition. The urine may be slightly blood stained, or if there is an acute cystitis with much strangury it may be profuse. It quickly responds to rest in bed.

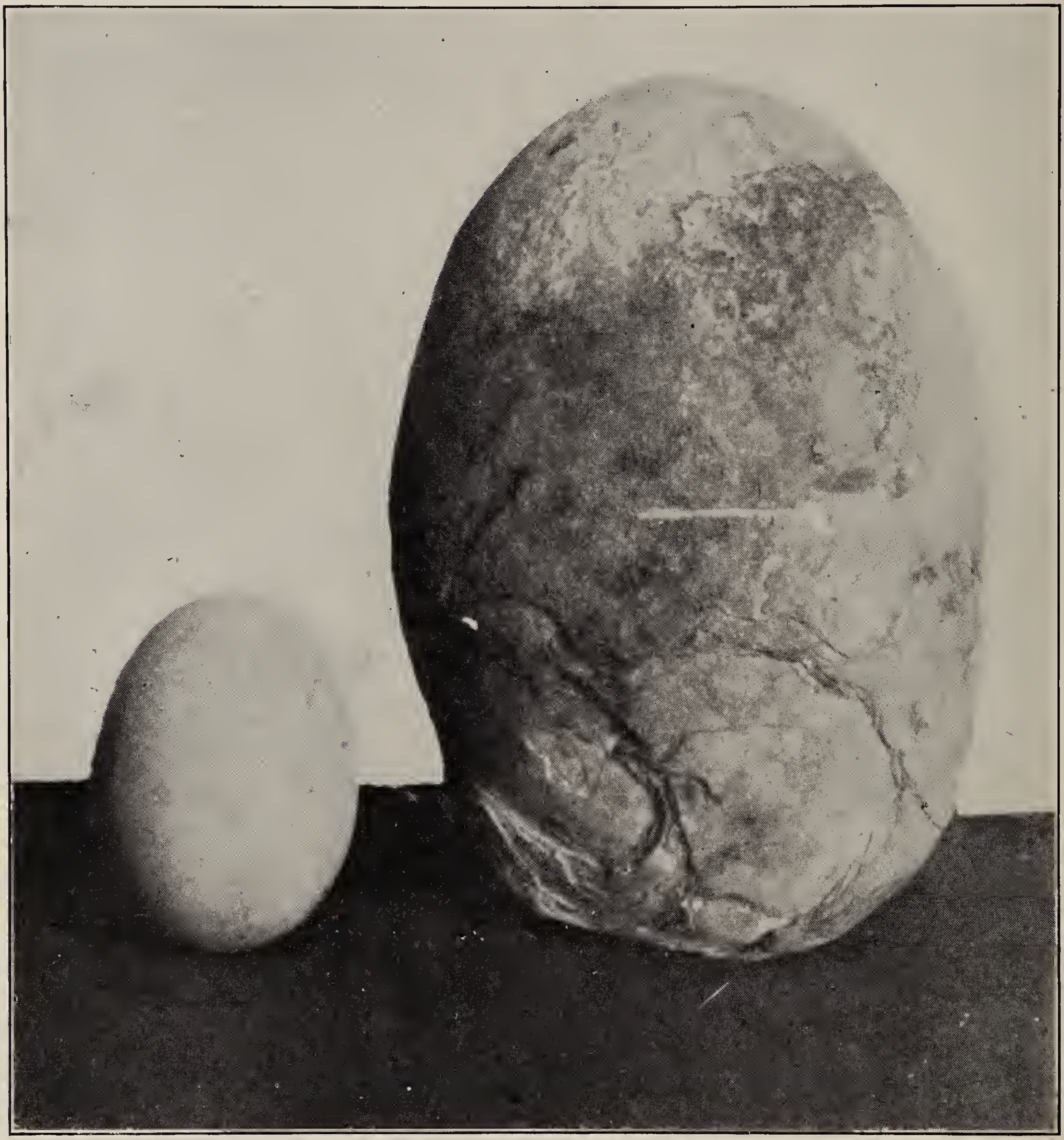

FIG. 39. Calculus shown in Fig. 38 with hen's egg in comparison (Author's Case).

The physical findings show nothing characteristic, some predisposing factor must always be sought for.

The urine shows pus, the amount depending on the superadded infection. Red blood cells are rarely absent. The reaction of the urine is frequently alkaline.

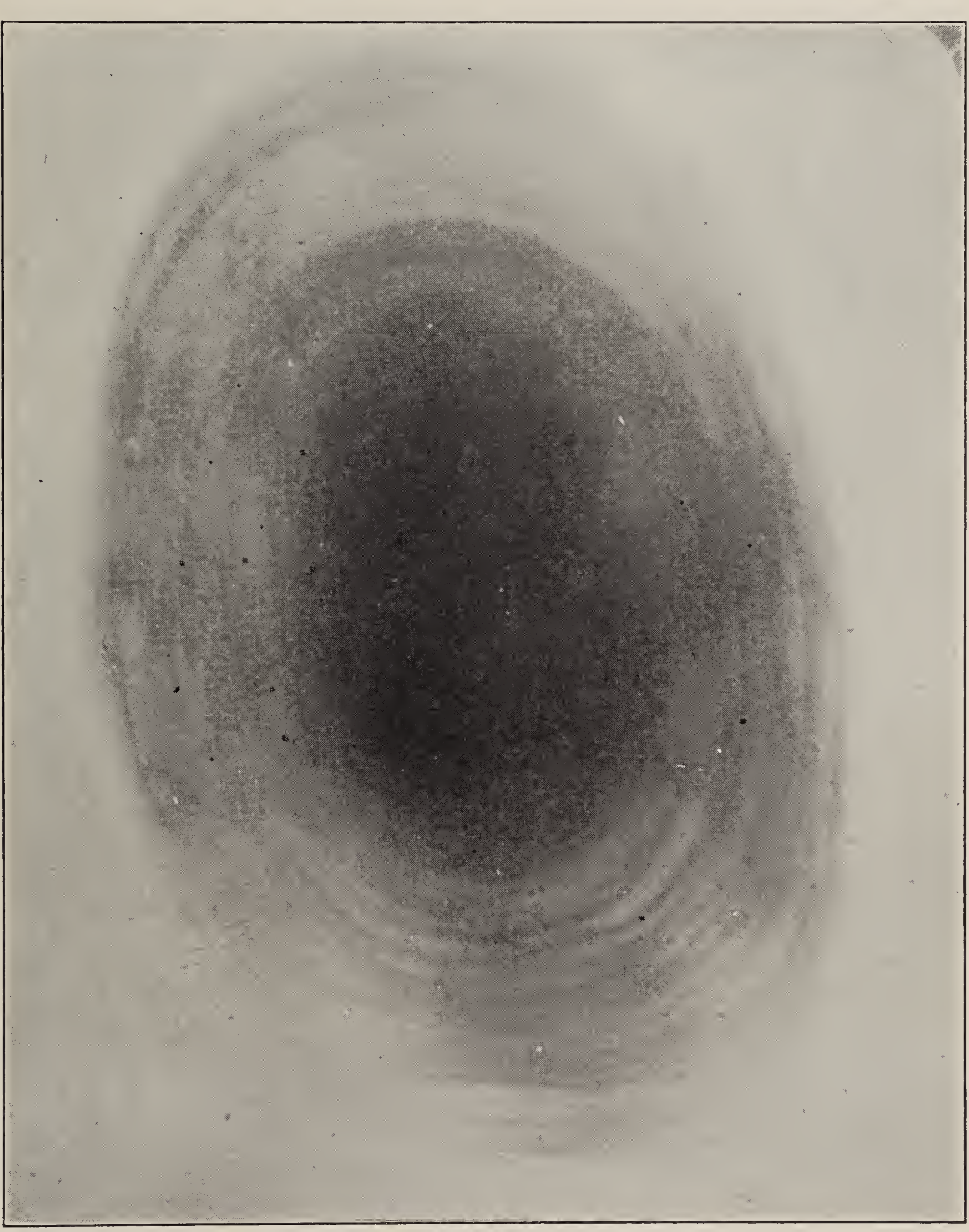

FIG. 40. Cross section of calculus (Author's case).

Diagnosis. X-ray examination is particularly unreliable in the detection of bladder stones, in contradistinction to renal and ureteral calculi. This is due to the fact that the former are more frequently composed of

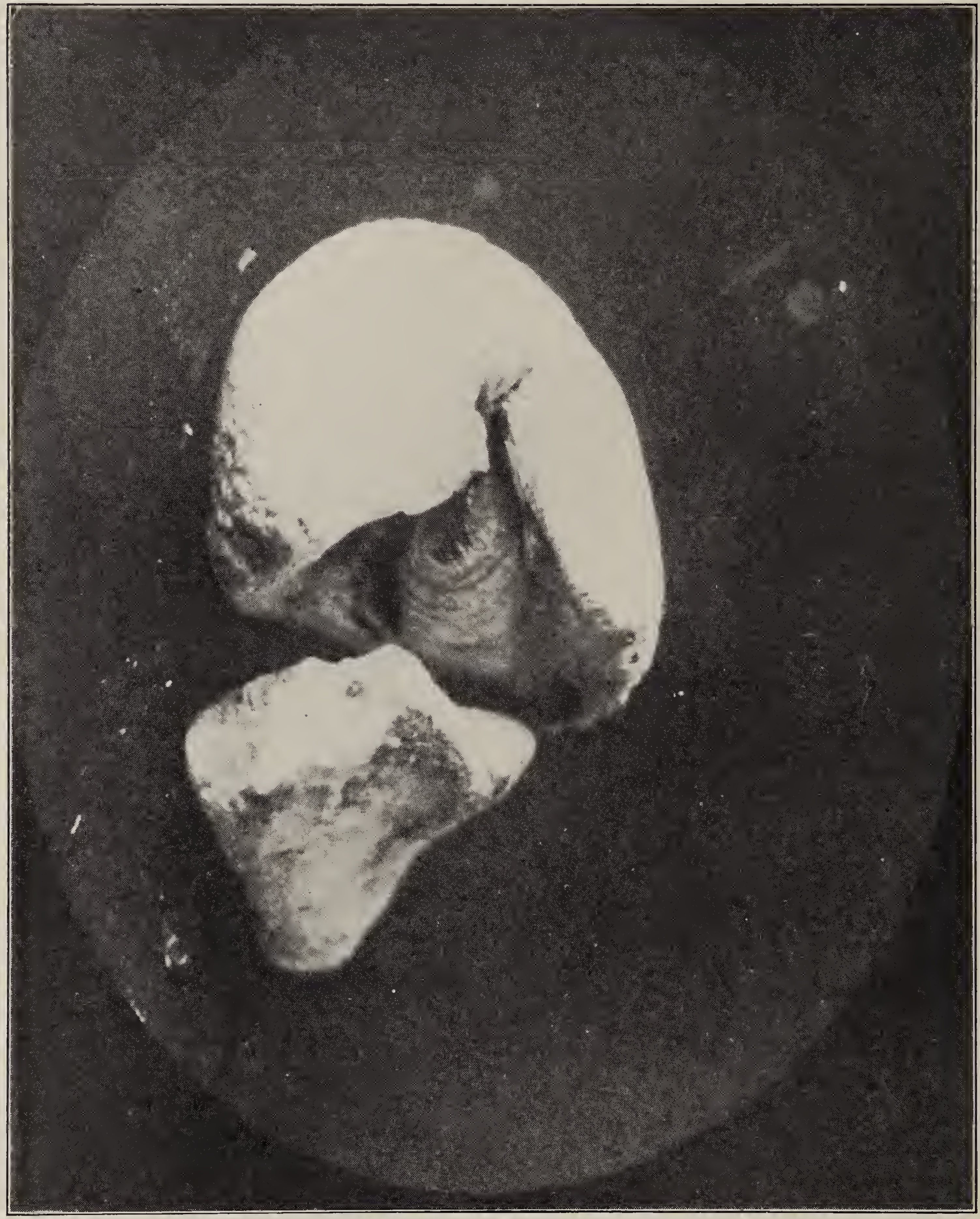

Fig. 41. Photograph of impacted urethral and vesical calculus removed from female bladder (Author's case).

urates and the tissues about the bladder, lacking gas, do not throw the stones in relief. Cystography may thus disclose calculi which do not cast a shadow.

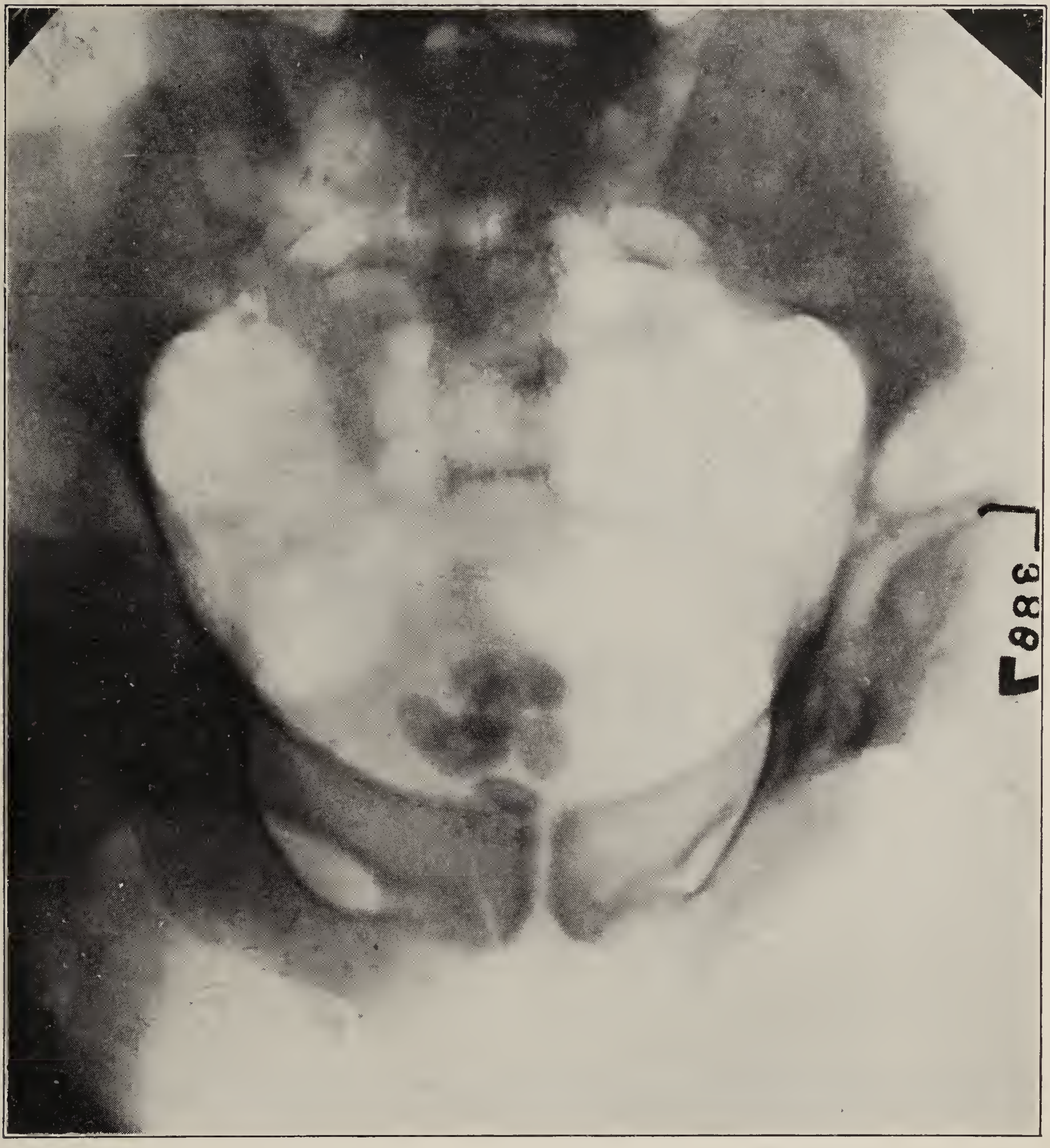

Fig. 42. Skiagraph of multiple vesical calculi (Author's case).

Sounding for stone, once so generally employed, has been largely supplanted by the cystoscope. As in other conditions this is the instrument which gives accurate information, not only regarding the foreign body but as to associated conditions. Without it many stones are overlooked and accurate diagnosis impossible. Stone must be differentiated from slough and tumor encrusted with phosphates.

The differential diagnosis is chiefly concerned with associated conditions, e.g., strictures, prostatism, etc.

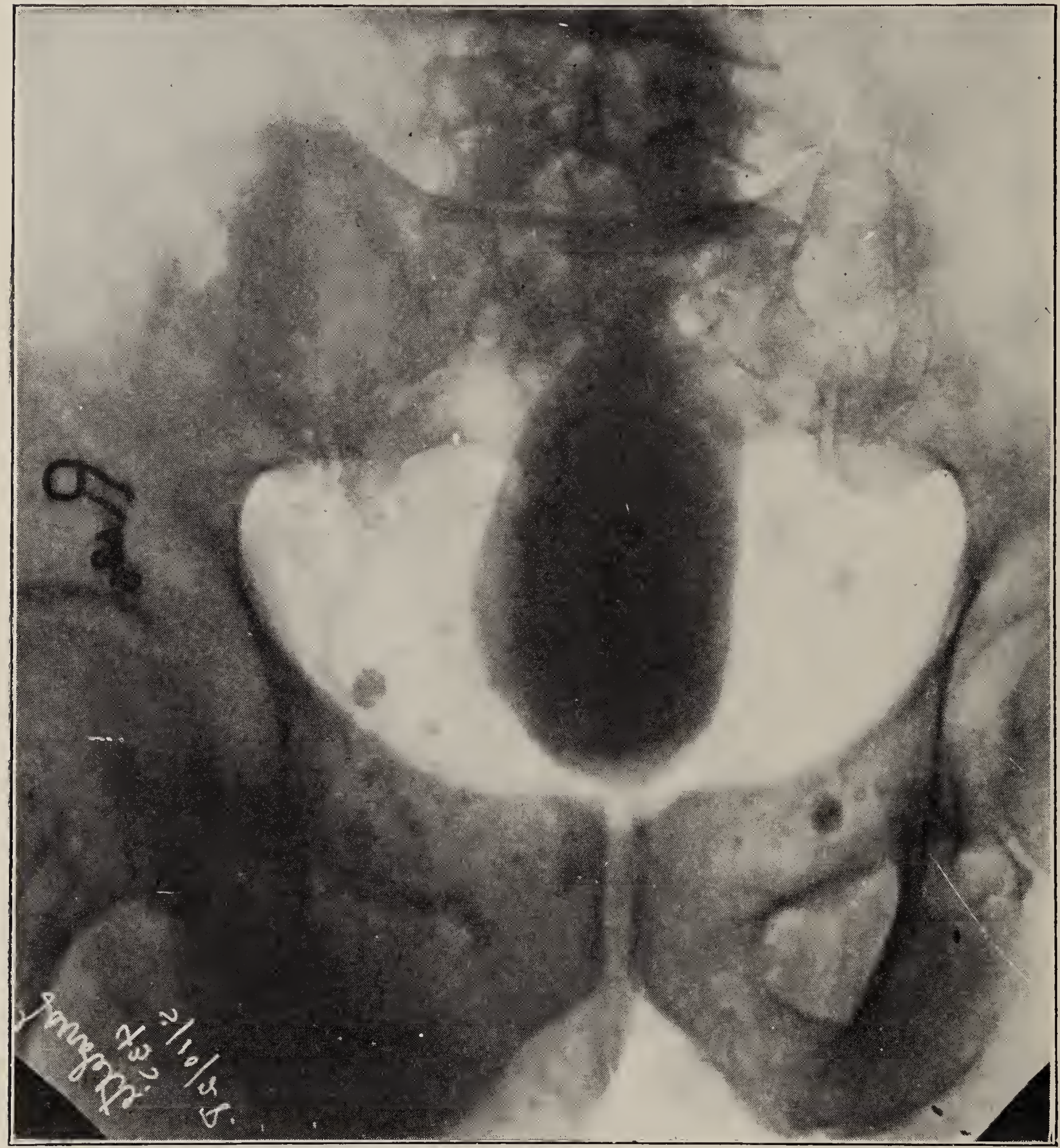

FIG. 43. Skiagraph of large vesical calculus in prostatism (Author's case).

In young adults tuberculous cystitis must be borne in mind. The symptoms are essentially the same except that frequency is characteristically most marked during the day in vesical calculus, and during the night in tuberculosis. A history of tuberculosis elsewhere, a nodular prostate, seminal vesicle or epididymus is an important point and will often lead one to a search for the bacilli in the urine. A markedly impaired kidney function as determined by the phenolsulphonaphthalein or other tests

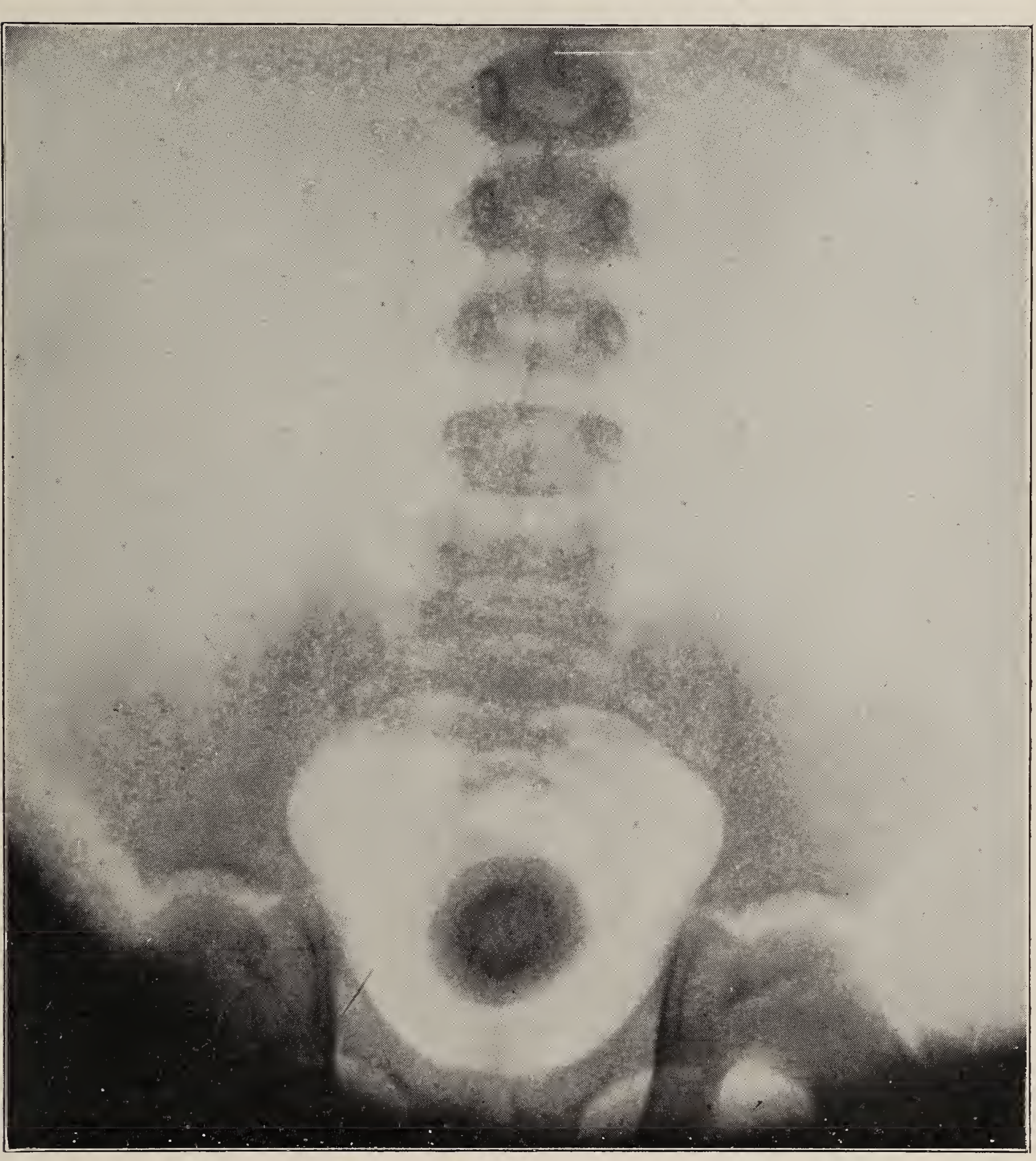

FIG. 44. Skiagraph of vesical calculus in six-year-old boy (Author's case).

strongly suggests vesical calculus, as this is a late phenomenon in renal tuberculosis.

The treatment is purely operative; where there is long-standing retention with much infection the operative risk may be improved by a preliminary period of rest in bed with forced fluids and urethral drainage.

The operative procedures are:

(1) Litholapaxy.

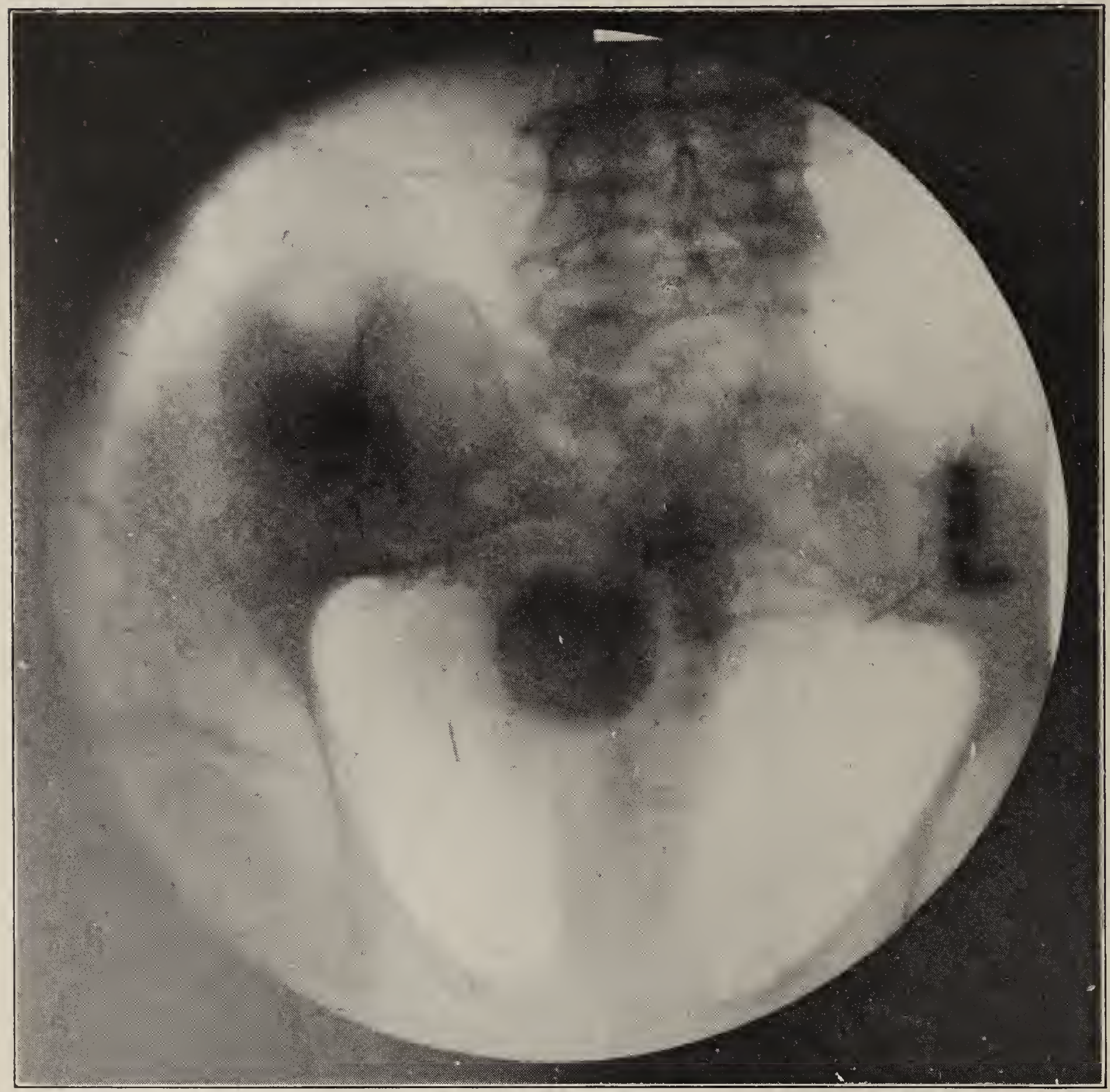

FIG. 45. Skiagraph of calculus in diverticulum of bladder (Author's case).

(2) Perineal lithotomy.

(3) Suprapubic cystotomy.

Litholapaxy as originally practiced is an operation only to be attempted by an expert. Cabot on this continent is the chief exponent of litholapaxy. In the hands of so experienced an operator the results are brilliant, but few others are competent to perform this operation. It is then only applicable to stones which are not too hard or too large, they must be free in the bladder cavity and there must be no urethral obstruction.

Suprapubic cystotomy is the procedure of choice in the majority of cases. It is essential if the stone is very large or the bladder much inflamed. It can be performed with a minimum of shock to the patient and enables one to deal with the enlarged prostate or other associated conditions. Local anæsthesia will be sufficient unless the stone is large, or marked pericystitis be present, or unless one wishes to explore the vesical

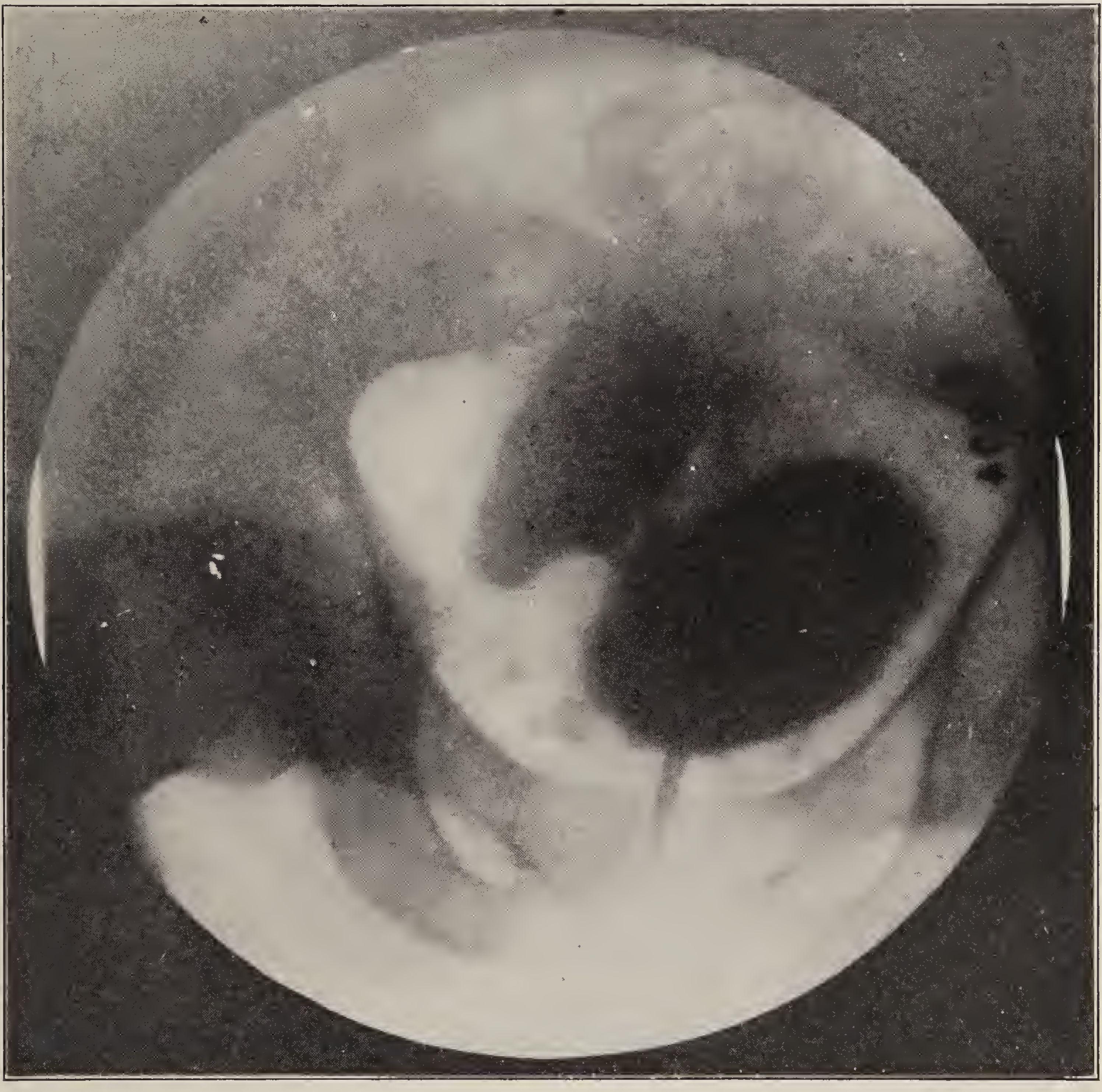

Fig. 46. Cystogram showing diverticulum of bladder with calculus. Diverticulum the seat of carcinoma (Author's case).

neck. For these cases nitrous oxide and oxygen may be given after the bladder is exposed and will usually be sufficient.

Spinal anæsthesia is usually quite efficient, although it is not particularly suitable for feeble patients with low blood pressure.

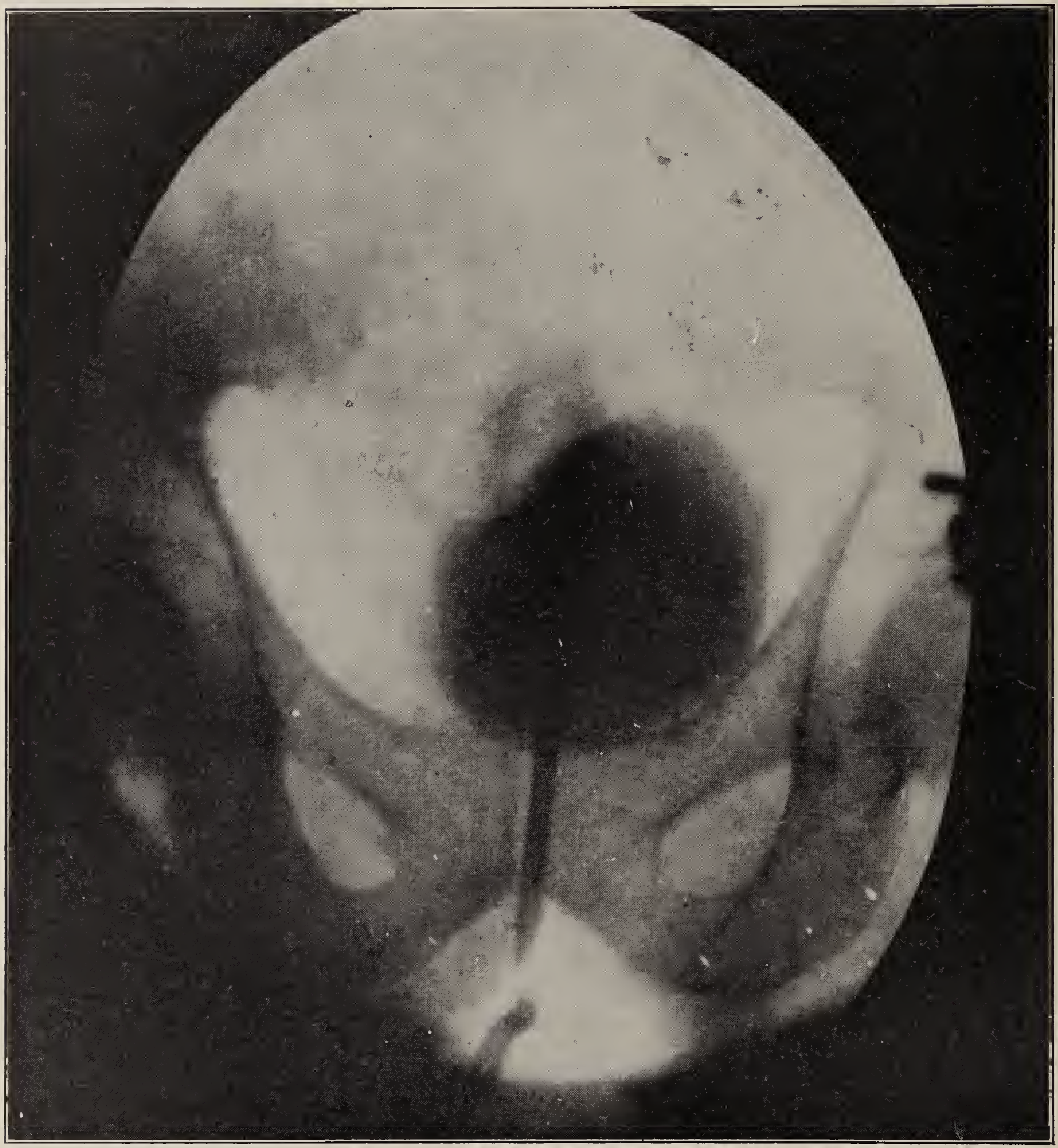

FIG. 47. Cystogram following removal of calculus and resection of carcinomatous diverticulum (Author's case).

The technique of suprapubic cystotomy is described under traumatic injuries to the bladder. There is little difficulty in removing the stone unless it be large or encysted.

The post-operative treatment is most important, the object being to clean the bladder and to stimulate the damaged kidneys. The bladder is irrigated daily through the suprapubic tube with a solution of warm boracic acid, normal salt, or silver nitrate 1 in 10,000. Fluids are forced by mouth and in toxic cases per rectum, subcutaneously or intravenously.

Prevention of recurrences. Recurrence of vesical stone can be prevented by correction of any condition tending to produce urinary stasis; by changing the reaction of the urine as indicated by the type of salts predominating in the stone; by eradication of local and remote foci of infection and by forcing fluids in order to avoid concentration of the urine.

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TUMORS OF THE BLADDER

While tumors of the external organs and exposed surfaces have never offered any difficulty of recognition, it has been quite different with tumors of the internal, inaccessible, organs such as the bladder.

Until the advent of the cystoscope bladder tumors were practically never recognized early enough to attempt anything more than palliative treatment. Nitze of Berlin was the first to perfect a cystoscope which enabled him to recognize and to study the peculiar structural characteristics of papillomata of the bladder and their tendency to recur after surgical removal.

In 1896 he published a large series of cases which he had cured by cauterization through his cystoscope. Although his instrument was far from perfect and he drew much criticism from his contemporaries, he had made a real contribution to urology.

Beer perfected this method and brought it into general use on this continent about fourteen years later. His treatment by high frequency current of benign papillomata was very satisfactory and continues to be so, but was found to have such a limited application to malignant growths that suprapubic excision came into general practice, Beer himself being one of the pioneers with Squires, Young, Lower, Judd, Thompson-Walker, Albaran and others in the development of this method.

The inaccessibility of the majority of these growths, due to the frequency of association with the ureteral orifices and their occurrence about the trigone and vesical neck, made excision a very difficult and troublesome procedure and frequently inadequate. This has led to our modern methods of suprapubic cystotomy with electrocoagulation (Corbus and Thomas) and various other forms of cauterization (Percy and others). Radium has been largely employed both by suprapubic and endovesical implantation, the methods having been perfected by Geraghty, Barringer, Kelly, Burnham and others.

Definition. A tumor consists of groups of cells which for no apparent reason reproduce themselves in an abnormal disorderly fashion and grow irrespective of their surroundings or of the needs of the organism that produces them.

Classification. Papilloma and carcinoma comprise the large majority of tumors encountered in the bladder and are of epithelial origin. Less frequently sarcoma, adenoma, and fibroma may be seen, and exceptionally angioma, myoma, rhabdomyoma and leiomyosarcoma. Dermoid and hydatid cysts have been described. The following classification by Geraghty is simple and comprehensive.

- Tumors of epithelial origin
    - Papilloma
        - Benign
        - Malignant
    - Adenoma
    - Cysts
    - Carcinoma
        - Papillary
        - Schirrous
        - Squamous
        - Adeno
- Tumors of connective tissue origin
    - Sarcoma
    - Myoma
    - Fibromyoma
    - Angioma
- Tumors of muscle origin
    - Myoma
- Heterogeneous
    - Rhabdomyoma
    - Hydatid cysts
    - Dermoid cysts
    - Chondroma

The bladder may be involved secondarily as a result of extension from a neighbouring viscus, particularly the prostate, cervix uterus and bowel.

Barringer's classification resembles closely the above and is as follows

Primary bladder tumors.

From epithelial tissue:
1. Papilloma.
2. Papillary carcinoma.
3. Infiltrating (non-papillary) carcinoma.
    - *a.* Simple carcinomatous ulcer.
    - *b.* Flat squamous-celled carcinoma.
4. Adeno-carcinoma.
    Generally secondary to prostate, but very rarely primary, and if so, originating in Limbeck Brun glands.
5. Colloid carcinoma.
    From Limbeck Brun glands (rare).

From connective tissue:	Fibroma Myxoma Sarcoma
From muscle tissue:	Myomata
Heteroptic Forms	Chondroma Rhabdomyoma Dermoid
Cysts	
Secondary bladder tumors: To prostate	Fibro-carcinoma Adeno-carcinoma Adenoma Fibro-adenoma Sarcoma (young adults)
To seminal vesicles	Carcinoma
To intestinal tract	Glandular carcinoma Adeno-carcinoma Mucous carcinoma
To cervix	Squamous carcinoma Adenoma-carcinoma (rarely)
To vagina	Sarcoma (especially in children)

Kaufmann has called our attention to the frequency with which tumors of the prostate involve the bladder, and Barringer has noted that the converse is rare. The author has noted several cases where carcinoma of the prostate had involved the bladder. Secondary growths commonly appear as knobs or plates covered by relatively normal mucosa or with slight sloughing, but may resemble papillomata or myomata. Such secondary growths usually are readily diagnosed on rectal or vaginal examination revealing a hard, nodular prostate or ulcerated cervix, and in malignant disease of the intestine by a barium X-ray series or enema.

Etiology. Nothing more is known of the etiology of tumors of the bladder than of tumors elsewhere. Long continued irritation in the form of chronic infection appears to have some influence. When one remembers that the bladder epithelium is made up of sensitive transitional cells whose structure is constantly changing and that papillary formation takes place with the greatest ease, it will be seen how readily proliferation can take place. Chronic irritation also is said to be a factor in tumors occurring in the bladders of persons working in aniline dye factories, due to the inhalation and subsequent excretion of irritating substances. Rhen of Frankfurt has called attention to this, and more recently Oppenheimer, also of Frankfurt, has added an interesting contribution. He found that not only were the workers likely to be affected but anyone living in the vicinity of these numerous factories. The tumors were always of the epithelial type and slow growing. Of 37 cases, 27 were malignant and 10 benign.

Tumors occasionally are associated with calculi. Hadda describes a case occurring five years after the removal of a stone. The author has recently observed two such cases, one occurring in a woman who had had a stone removed by litholapaxy sixteen years previously, the other in a man from whom a stone was removed five years before by suprapubic cystotomy. Fuch found calculi in nine out of 189 cases of tumor of the bladder. These cases are of such frequent occurrence as to be considered other than coincidence. Their association with diverticula is a well recognized fact; the author has had several such associations. Like tumors elsewhere they are more frequent as age advances, although papillomata are not uncommon in young adults. They are much more common in men than in women.

Our series from the Department of Urology of the Royal Victoria Hospital follows:

Total number of patients........		326
Males		248
Females		78
Youngest patient		23 years of age
Oldest patient..................		88 " " "
Age periods:	20–30 years of age	5 cases
	31–40 " " "	14 "
	41–50 " " "	63 "
	51–60 " " "	99 "
	61–70 " " "	103 "
	71–80 " " "	40 "
	81–90 " " "	2 "

They can arise at any period of life from two and a half years up (Ewing).

Type of growth:

1.	Papilloma benign	122	cases
2.	Papilloma malignant	137	"
3.	Carcinoma	59	"
4.	Sarcoma { mixed type	1	"
	round cell	1	
5.	Fibroma	2	"
6.	Angioma	1	"
7.	Rhabdomyosarcoma	1	"
8.	Leiomyosarcoma	2	"
	Total	326	

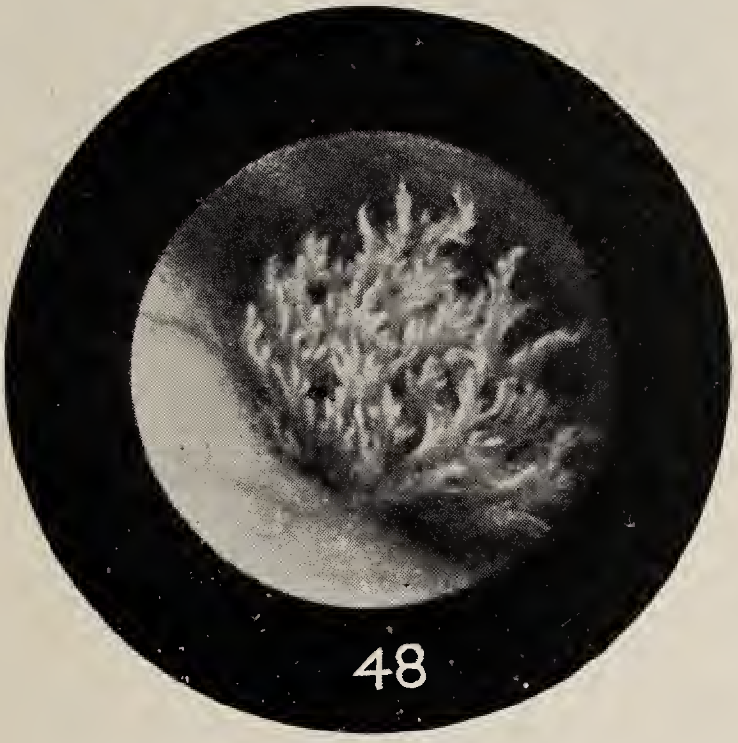

FIG. 48. Cystoscopic view of a papilloma of the bladder. Note the fine villous processes (Mercier).

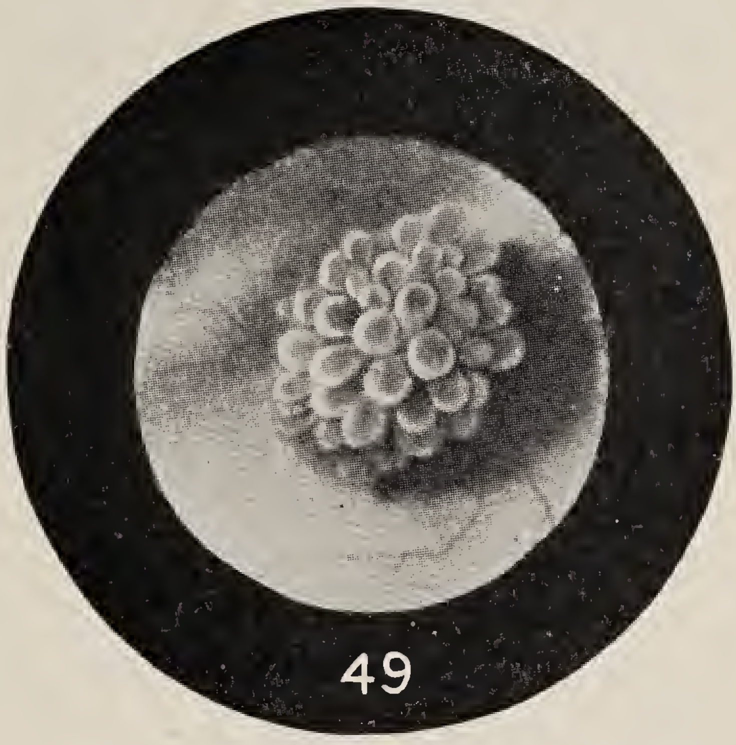

FIG. 49. Cystoscopic view of a benign papilloma of the bladder. There are no villous processes but the tumor is made up of many cystic-like bodies (Mercier).

Pathology. The bladder papilloma, though usually classed as innocent, is much more likely to become malignant than papillomata elsewhere. In its typical form it appears usually in the neighbourhood of the ureteral orifices, as long, villous processes which float out like seaweed when the bladder is full of fluid. They may occur singly, there may be a parent tumor with a number of smaller ones around it, or the entire mucous membrane may be studded with villous growths. Although the pedunculated type is most common, sessile forms are frequent, and it is stated that this type is more prone to acquire malignant characteristics. (Figs. 48, 49, and 50.)

It is extremely difficult to tell even on microscopic examination, whether or not a given section of a papillomatous growth is malignant or benign. "That a tumor conforms grossly and even microscopically to the papilloma type is no proof that its complete removal will not be followed by recurrence, either in the form of papilloma or cancer."

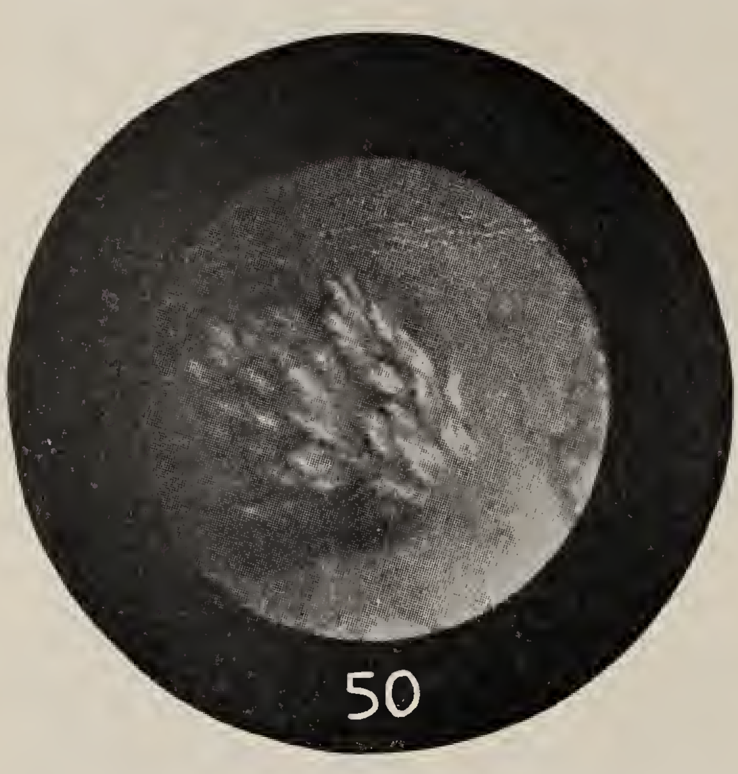

FIG. 50. Cystoscopic view of a fungating papillomatous growth of the bladder (Mercier).

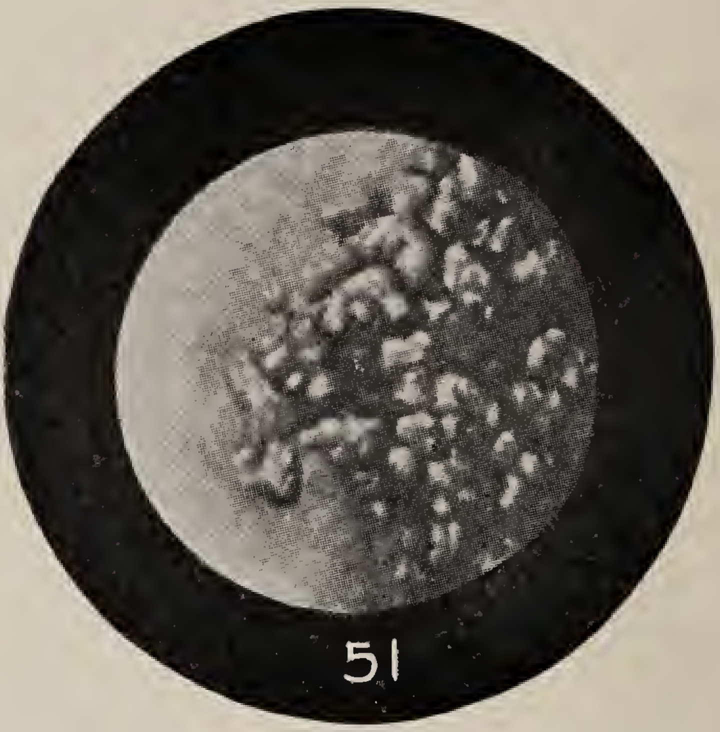

FIG. 51. Cystoscopic view of a malignant papilloma of the bladder. Note the shaggy cauliflower-like masses (Mercier).

(Keyes.) In a general way, one may say that typical benign papilloma occur earlier in life, are pedunculated and readily destroyed by fulguration. The malignant growths occur in older people and tend to ulcerate, the surface may be covered with calcareous slough and the base infiltrated. They heal slowly and imperfectly after fulguration. Microscopically there is seen to be a fine connective tissue and vascular framework covered with transitional epithelium. Those characters which suggest malignancy are irregularities in shape formation and staining reaction of cells, atypical mitoses, loss of basement membrane and giant cells. Any penetration of the surface epithelium into the deeper connective tissue planes is pathognomonic. Adenoma, myoma, fibroma, angioma and cysts are rare and retain their characters as innocent tumors.

Carcinoma is common and may originate as such or as a further development of a papilloma. The usual types are: — (1) A papillary form which appears as a shaggy cauliflower-like mass which may show ulceration and bleeds freely. (Figs. 51 and 52.) (2) The infiltrating type which is likely to be ulcerated and covered with calcareous slough. (Fig. 53). The microscopic characteristics of this type verge toward the squamous epithelioma.

Sarcoma is less common and may occur in any form, no variety being characteristic.

Rhabdomyosarcoma and leiomyosarcoma are excessively rare and are usually described as showing little tendency to metastasize. We have during the past year encountered one case of the former and two of the latter in our clinic at the Royal Victoria Hospital, and each was phenomenal in that widespread metastases occurred with amazing rapidity.

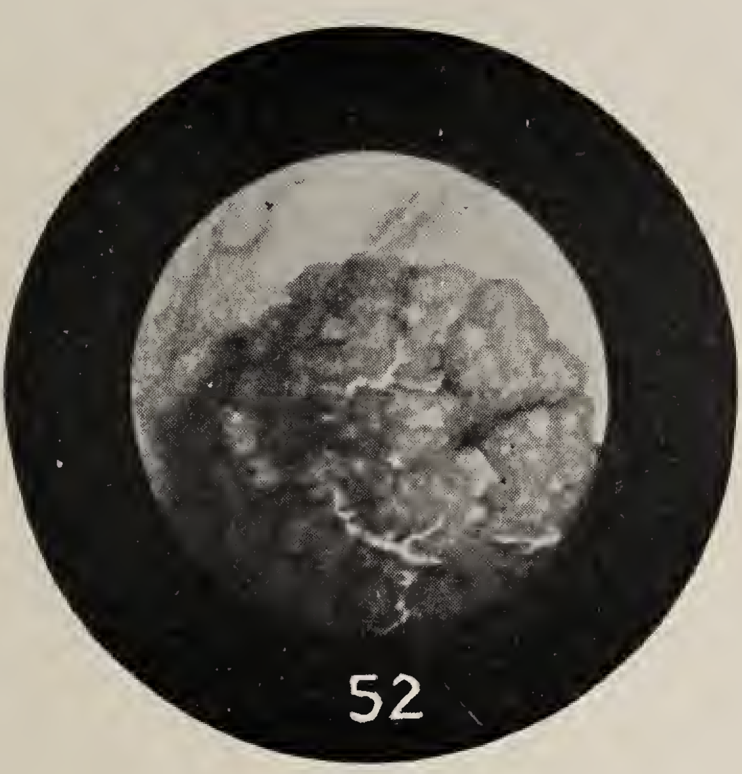

Fig. 52. Cystoscopic view of a malignant papilloma of the bladder. Note the large cauliflower-like mass which shows evidence of ulceration (Mercier).

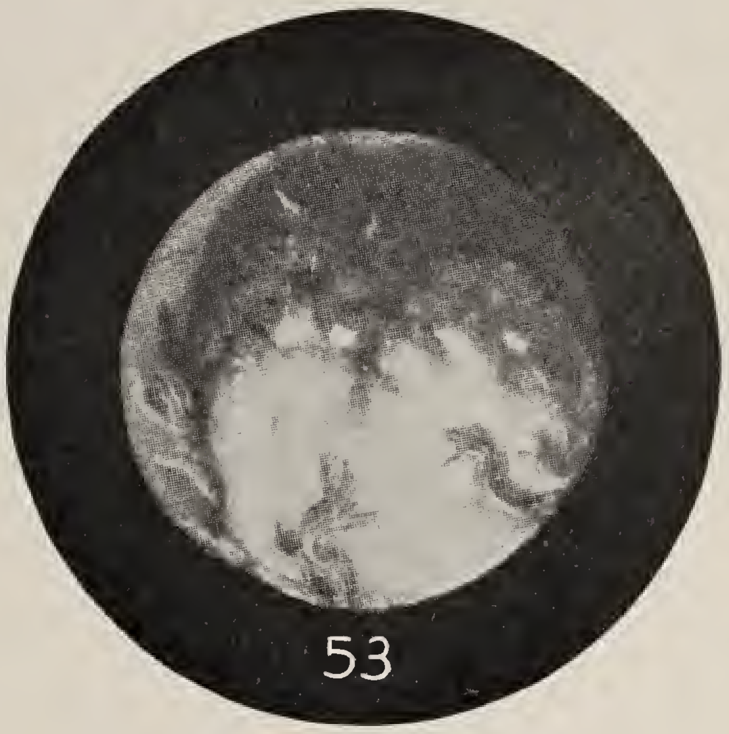

Fig. 53. Cystoscopic view of an infiltrating carcinoma of the bladder covered with calcareous slough (Marion and Mercier).

Symptoms. Bladder tumors are found in all ages from childhood to old age. Papillomata are more common between 40 and 55 years of age and carcinoma about a decade older.

Sex. Benign and malignant growths of the bladder are much more common in males than in females. Barringer in 153 cases of carcinoma found 119 in males and 34 in females. In ours, taking all bladder growths, 248 were in males and 78 in females.

The most characteristic and most striking symptom is hæmaturia. It appears for no apparent reason, is unaffected by rest or medication, may be slight or profuse, and ceases as it began without apparent reason. There may be long intervals of months or even years between the hæmorrhages when the patient feels that he is well and does not seek advice, but usually as the disease progresses it recurs more frequently, and becomes more profuse. The urine may be only tinged, it may be a deep burgundy with many clots, or there may be blood at the end of the act from the compression of delicate villi as the bladder contracts.

Albaran cites a few cases in which hæmorrhage stopped entirely following spontaneous detachment of the growth.

Pain and dysuria are exceptional until the disease is advanced, and is due either to the passage of clots, occlusion of the urethra by a pedunculated growth, slough, or malignant infiltration of the bladder neck. Any one of these factors may, indeed, cause retention.

Usually as the disease progresses infection supervenes. The tumor is a point of lessened resistance where the infection begins and characteristically progresses to an anatomical cystitis leading occasionally to incontinence and marked dysuria with the passage of foul urine.

The physical findings are negative at the outset and the patient may continue in good health for months or years, even with malignant tumors. Ultimately from the loss of blood, the aggravation of the cystitis or the dissemination of the growth, the patient becomes pale and anæmic and rapidly weakens.

The urine at first may contain only microscopic red blood cells, if there is no hæmorrhage at the time, with no pus and the reaction is acid, but as the disease progresses pus appears in increasing amounts with mucus, triple phosphates and even slough. Small pieces of tumor may be passed at any time and may assist in diagnosis, but it is rarely possible to differentiate papilloma from carcinoma from such a specimen.

Clinical history of a typical case. The patient gives a history extending over several months of attacks of painless hæmaturia, recurring at shorter intervals. The hæmaturia becomes more profuse and clots are passed which may cause distress. From this point the patient may progressively weaken from loss of blood, or dysuria may become marked. He voids frequently, is unable to sleep, has a great deal of pain over the bladder with perhaps difficulty in voiding and he quickly becomes cachectic. Finally induration may be felt in the rectum or vagina, the lymphatics along the iliac veins may be extensively involved with œdema of corresponding leg, the ureteral orifices may be involved with anuria, or metastases may occur in liver or lungs.

Course. The course of bladder tumors is long and generally very slow. As in the symptoms and prognosis the course depends greatly on the location and the type of the growth. " Guyon observed a case of thirty years duration " (Ewing). The author has operated on a case of multiple papilloma filling the entire bladder, with a history of intermittent hæmaturia for twelve years. They progress slowly and finally cause death from the loss of blood, anæmia and cachexia, kidney complications or less commonly metastases.

Diagnosis. Exceptionally an early tumor is diagnosed when the bladder is being examined with some other condition in view, and not infrequently we see patients who are manifestly in the terminal stages of malignant disease. With these exceptions the diagnosis of tumor of the bladder is made on cystoscopic examination after their presence has been suggested by a typical history of hæmorrhage. The importance of early examination of every case of hæmaturia will be apparent, as this is the only method which will enable us to make a diagnosis at a time when successful treatment may be attempted.

The cystoscope may fail in diagnosis when the tumor is very small and situated in an unusual position; when the tumor is so large as to fill the bladder and leave no cavity to illuminate; or when there is marked cystitis covered with phosphatic deposit. It is essential that one should search most carefully the area about the ureteral orifices and the vesical neck, as these are by far the most common sites for tumor growth; less frequently carcinoma may take origin at the vault, hence this area, too, must be carefully searched when tumor is suspected.

Removal of sections by the cystoscopic scissors for examination is well worth trial, but it is frequently impossible to make a diagnosis from such a specimen, and certain clinicians protest against the practice on the grounds of possible dissemination. The experienced clinician, however, will learn to make his diagnosis on the clinical features of the case and the characteristics as presented by the cystoscope. When there is any doubt it is best to consider the tumor malignant until its innocence is proven. Keyes states that the ultimate criterion will depend on the response to treatment. " The tumor that can be readily cured by fulguration is not malignant." The success or failure of fulguration treatment of papillary tumors of the bladder often determines their malignancy.

However, in a cystoscopic examination of a bladder tumor most authors agree that generally certain characteristics point to malignancy as single growth with ulceration on it, induration of the base of the growth, fixation of the base, and solidity of the growth.

The radiograph either with the bladder dilated with air or fluid as argyrol 10% will often help with the diagnosis. It is better when stereoscopic. (Fig. 54).

Metastases. Dissemination of malignant bladder growths to the other parts of the body are generally late. Extension takes place by way of the pelvic lymphatics to the prevertebral lymph nodes and the spine. In our series three had evidence of secondary growths in the sacrum and iliac bones, one had metastases in the sacrum and upper third of right femur. (Fig. 55.)

Bone metastases are of the rarifying destructive type. Kretschmer gives three cases with early bladder growths and bone metastases.

Cunningham's series showed 50% with metastases. He also quotes Barringer and Bumpus with about the same percentage.

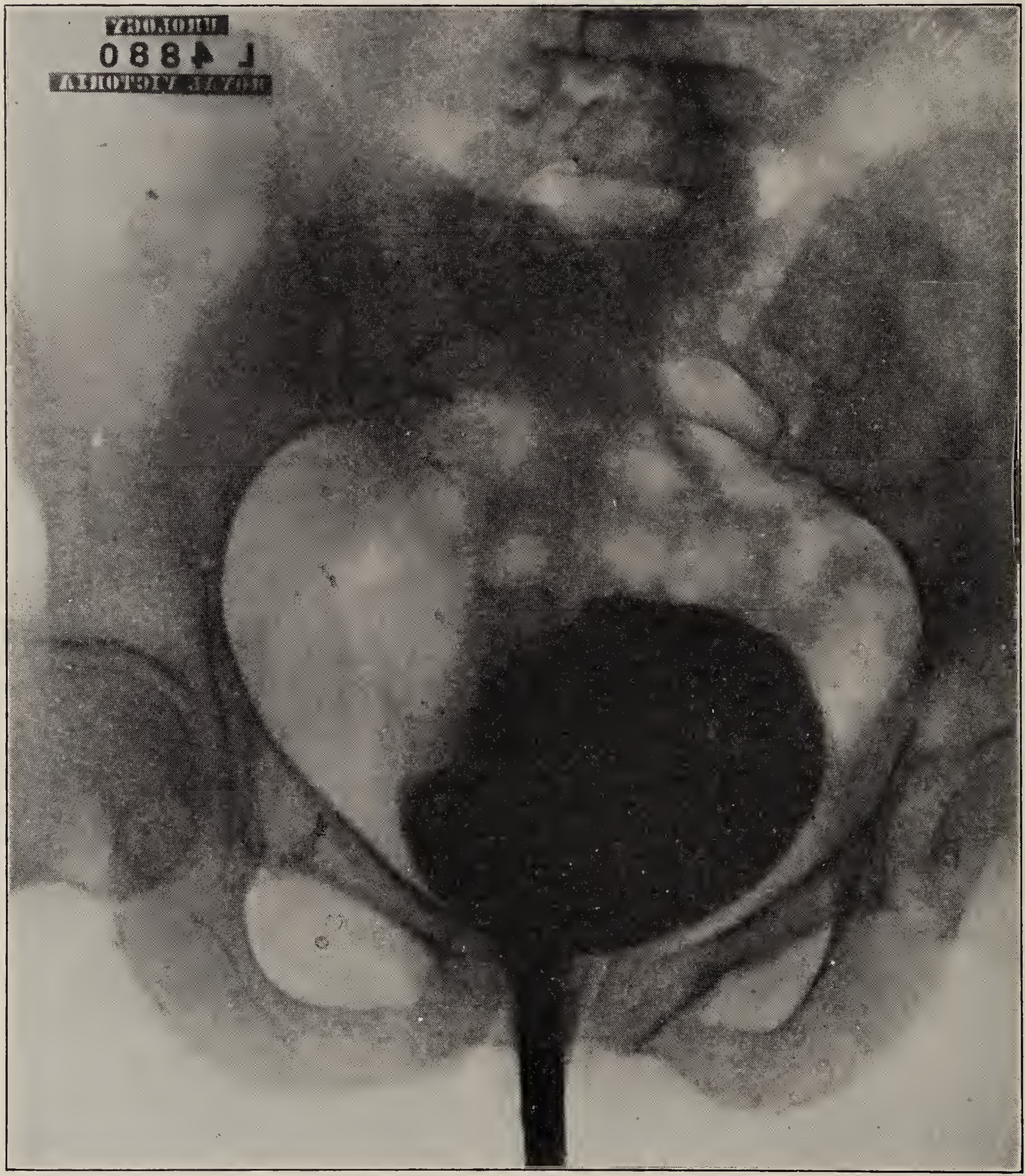

FIG. 54. Picture of a cystogram with ten ounces of 10% argyrol. Note the large filling defect on the left side (Author's case).

Differential Diagnosis. Pathological conditions of the bladder easily deceive the examiner, especially if hurried or careless, and bladder tumors may be confused with ulcer, old blood clot, calculus, tuberculosis, leukoplakia, etc.

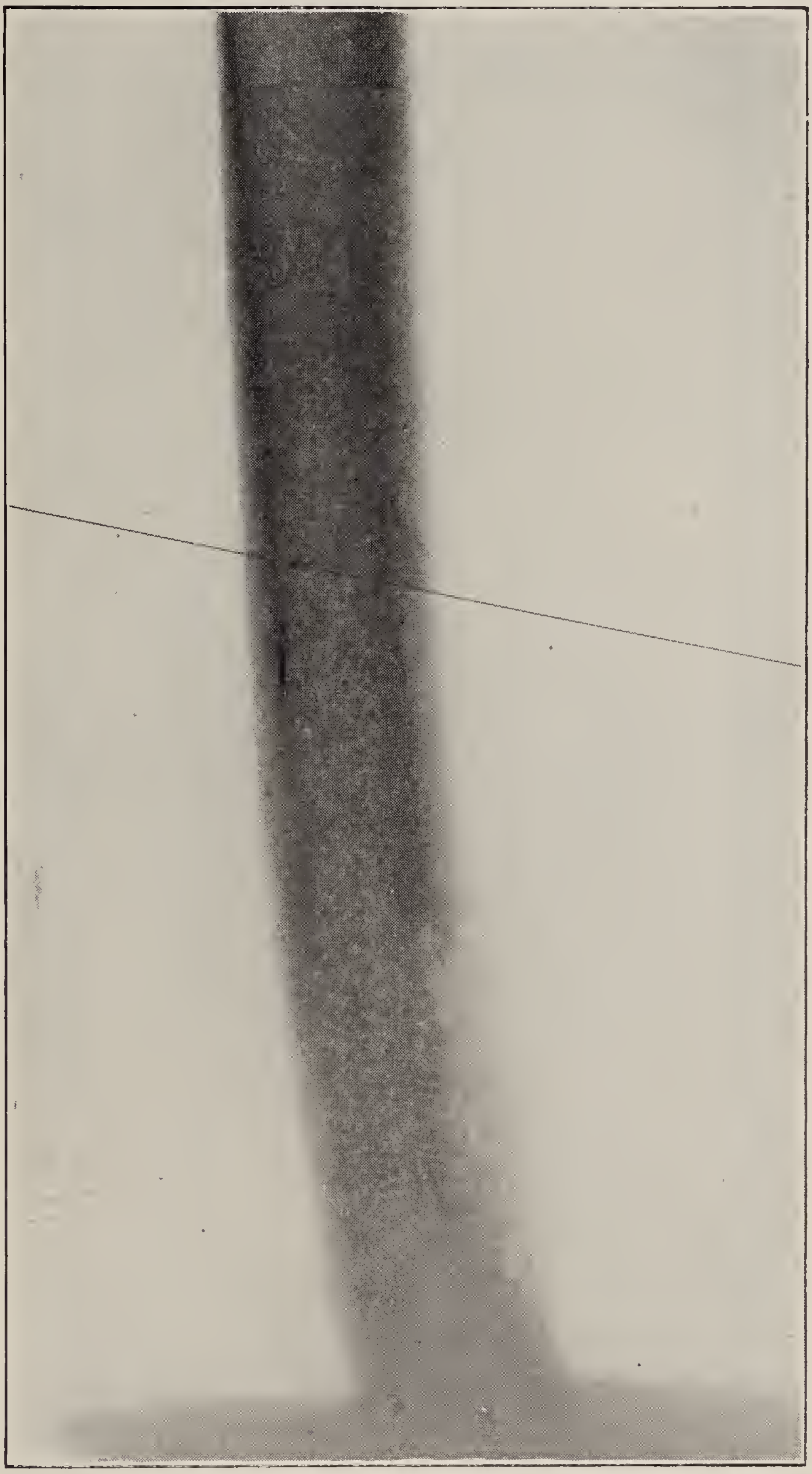

Fig. 55. X-ray showing metastases in the upper third of the right femur from a carcinoma of the bladder (Author's case).

Treatment. There are several methods used today in the treatment of tumors of the bladder. The procedure adopted depends upon the following factors: (1) The type of the growth. (2) The size of the growth. (3) The multiplicity of growths, and (4) The site of the growth.

The following are the methods used: —

(1) High frequency endovesically (cystoscope).
(2) Radium endovesically and suprapubically.
(3) Suprapubic cystotomy with diathermy (electro coagulation).
(4) Suprapubic cystotomy with excision.
(5) Suprapubic cystotomy with excision and diathermy.
(6) Suprapubic cystotomy with excision and transplantation of one or both ureters.
(7) Cystectomy with transplantation of both ureters.
(8) Deep X-ray therapy.

Cystoscopic fulguration is particularly applicable to single small papillomata and it is the ideal method of treatment of these cases. Nitze originated this method and Beer perfected it and published his first work in 1910. More extensive growths may be attempted in this way if the operator's experience warrants it. Special instruments have been devised for this purpose by Buerger, McCarthy, Kidd, Lowsley and others. Lowsley's instrument has a reinforced ebonite sheath and is used with the McCarthy telescope. The beak of the instrument is curved at the customary angle and is surmounted by an insulated, expanded metal tip, size 22 F., which acts as an electrode for the fulgurating spark. This instrument is designed to give a maximum field of vision and to obviate the objection to ordinary electrodes of the tip becoming blocked with destroyed tissue partially or completely insulating it. Tumors which resist such fulguration are of doubtful simplicity. It is difficult to say just what tumors one may attempt by the transurethral route, as stated, it is in many cases a matter of experience but certain definite contra-indications demand open operation.

1. When the growth is extensive.
2. When there are multiple growths.
3. When there is severe cystitis.
4. When there is urethral obstruction, stricture, or prostatism.
5. When the patient does not tolerate instrumentation.

In these types the operation of preference with many surgeons is suprapubic cystotomy with slow coagulation of the tumor. Thermoelectrocoagulation has been employed extensively, only of recent years and it is supplanting with many the older methods of excision and irradiation.

If the patient's condition is poor or there is evidence of exsanguination, a blood transfusion immediately preceding or following operation will be of assistance.

Ether is the anæsthetic of choice, but if for any reason it is contraindicated, the bladder may be exposed with local anæsthesia and the operation completed with the aid of nitrous oxide and oxygen. Similarly, spinal or sacral anæsthesia may be employed.

The bladder is well irrigated and partially filled with warm boracic, normal salt or acraflavine solution, as much as may be easily tolerated and the patient placed in the Trendelenberg position. The incision is made in the midline above the pubes and the bladder exposed in the usual manner, the peritoneal fold being well freed upward to the urachus. The urachal band is now doubly clamped and cut between. The bladder end is used to pull bladder forward. The sides of the wound are well walled off with gauze or towels. The bladder is gently palpated to avoid incising it at the site of the growth, and is now carefully and freely opened. With bladder retractors in position the pathology is carefully viewed; the Cameron light will be found useful here. The author uses the snare or cautery knife when possible to remove the bulk of a large growth, and also to obtain a satisfactory specimen. The growth or growths can then be slowly and very thoroughly coagulated. Following Beer's example, we now always use the alcohol following coagulation of extensive growths, hoping to lessen the possibility of implants on the bladder mucosa and in the wound. Young and Barringer both advise radium implantation. Barringer, after snaring the papillary portion, implants radium gold seeds of 2 mc. each in the indurated base of the growths, using one seed to one and a half square cm. "The seeds are inserted by means of a needle thrust into the tumor, and injected by pushing the plunger home. If no induration, radium tubes, screened by ½ mm. of silver, and 1 mm. of rubber, are packed against the base of the tumor. As a rule 200 or 300 nc. in an area 2 cm. square is sufficient." His results are good, and the author has frequently adopted his method, the only objection being the uncertainty of the time until the slough from the radium separates. One of our cases with a perfect result finally, took over a year to free himself of this slough. Coagulation and radium are both more suitable with many operators than excision for tumor of the base of the bladder and vesical neck. Extraperitoneal excision of the tumor is the operation of choice with us for indurated growths of the vault and vicinity. Beer advocates this operation in benign growths that are not readily accessible for endovesical high frequency treatment, for malignant growths with only moderate infiltration. His description of his operation is as follows:

"1. The bladder is gently irrigated, and then emptied, so that when it is opened, the wound is not flooded with fluid containing tumor-cells.

2. The patient is placed in moderate Trendelenburg position, and a wide vertical suprapubic incision made.

3. As the bladder is exposed extraperitoneally, it is freed from its bed of fat and peritoneum by blunt dissection to either side of the urachus, which is doubly clamped and cut between. The clamp in the bladder end of the urachus is used to draw the bladder forward and towards the symphysis as the peritoneum is sponged off its posterior surface. This may be opened accidentally, and will allow of palpation of the extent of infiltration, etc., of the walls of the bladder.

4. After the bladder has been well freed down to the trigone in this manner, and delivered well out of the abdomen, the perivesical space is carefully packed off with several layers of gauze abdominal pads, which protect the perivesical space and the incision in the parietes.

5. Then, depending upon the position of the growth or growths, the bladder is incised either through its anterior, its posterior, or its lateral walls. The incision should be gradually enlarged, so that wipes can sponge up the little fluid that may be in the viscus. Sponging within the bladder should be reduced to a minimum. As the incision is enlarged, the papillary growth will become evident, and it is immediately cauterized in situ with the electric cautery (hook) or with the Paquelin (hooked point). In cases of multiple growths, each growth is separately burnt, and every suspicious point is treated similarly. A too extensive cauterization is preferable to a too superficial. If the papillary growth is so large that it cannot be treated in this ideal manner, it may be seized by a blunt ring clamp, and delivered piecemeal till the pedicle is reached, when a carmalt-curved clamp is placed across this, and the cautery slipped between the clamp and the bladder wall. If the bladder wall is infiltrated, a wide cautery resection of this area is carried out. If the ureter is involved in the infiltrated area it is left attached till this area is resected and then cut away from the resected portion at a distance from the growth. Thereafter it is implanted in a healthy part of the bladder just before the bladder wounds are sutured.

6. Having a rather deep cavity to expose, it is wise to use retractors of different sizes and lengths rather than automatic retractors, so that all surfaces of the organ may be gone over readily, and none are covered except momentarily by the blades of the retractors. Again, to hold the organ well out of the body, clamps without teeth are applied to the bladder incision as it is being made. The use of the clamps with teeth, such as the Kocher, which produce minute perforations in the bladder wall, thus possibly producing implants, should be avoided.

7. Being satisfied that all the visible tumor or tumors have been destroyed, our next efforts are directed against possible cell implants. These may be in the bladder incision, loose in the bladder or on the gauze protective packings about the organ. The incision which opened the bladder is carefully seared with the cautery, proceeding from clamp to clamp in orderly fashion, each clamp being removed in turn as the cauterization proceeds. Then the table is lowered, and the whole wound is filled for about five minutes with alcohol, the bladder being allowed to slip back into its bed, so that its cavity as well as the protective gauze is exposed to the effects of the alcohol, which it is hoped will coagulate any potential cell implants that have broken away during the various manipulations.

8. After this thorough bath in alcohol the gauze protective packings are removed, fresh gauze being substituted. The bladder is sponged dry, and its incision is closed

after making provision for suprapubic tube drainage. (It is at this stage that the ureter is implanted in its new place.) In closing the bladder, a layer of plain catgut sutures is used to infold the charred edges of the incision, and over this a layer of chromic gut is applied to support the first layer.

9. The incision in the parietes is closed in layers, drainage with rubber dam or gauze to the bladder, both above and below the tube which enters that organ, completing the procedure.

For tumor of the vesical neck and trigone as well as for numerous scattered malignant growths we have on a few occasions done a radical total cystectomy after transplanting the right ureter in the cæcum and the left in the sigmoid. Beer and Coffey both recommend total cystectomy, each with different ways of treating the ureters. The author feels this form of treatment is applicable to only a small number of bladder tumors.

Deep Roentgen-ray has also been extensively used in many clinics, including our own. Apart from the occasional temporary relief of pain I cannot say I have found it of any curative value.

Prognosis. The great majority of bladder growths are of epithelial origin, either benign or of low grade malignancy.

The markedly malignant types are much less frequent.

Without treatment all bladder tumors progress, some slowly, some quite rapidly. Spontaneous cures are unknown.

With treatment the prognosis varies with the location, the type, and the extent of the growth. The results of treatment are growing more satisfactory every year.

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THE FEMALE URETHRA

BY

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THE FEMALE URETHRA

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Anatomy. The female urethra is the urinary passage leading from the bladder to the external urinary orifice in the vestibule. In comparison with the male urethra it is a short wide canal with easily distensible walls. At rest it is collapsed with the anterior and posterior walls in apposition, but is distensible by urination or artificial means to a width of from 7 to 10 mm., a fact important in estimating strictures, since many strictures giving symptoms are probably overlooked in the female because there is no obstruction to the flow of urine.

Anatomical relations. At its origin from the bladder the urethra lies opposite the middle of the symphysis pubis and about 2.5 cm. behind it. It is separated from the symphysis by connective tissue and the pudendal venous plexus. It runs from its origin downward and curves slightly forward to its external orifice in the vestibule about 1.5 cm. from the lower margin of the symphysis. In the upper part of its course for about 1 cm. it lies free and in this portion is entirely surrounded by a band of striated muscle. In the lower part of its course for about 2 cm. it is closely related to the anterior vaginal wall. For this distance the urethral and vaginal walls together with the small amount of connective tissue between them form the urethro-vaginal septum, a thin wall from 0.5 to 1 cm. in thickness. By digital examination through the anterior vaginal wall the urethra may be felt as a round cordlike thickening which may be rolled against the symphysis. In introducing instruments the slight anterior curvature of the urethra is entirely disregarded.

Orifices. The internal orifice of the urethra lies at the most dependent portion of the bladder trigone. It is lower than in the male, probably because in the male the prostate pushes the bladder trigone upward. In the female the internal orifice lies just above or below a line drawn from the lower border of the symphysis to the tip of the sacrum. Its shape is round rather than semilunar as in the male because of the absence of the bladder uvula.

The external orifice lies between the labia minora in the median line of the vestibule, about 2.5 cm. behind the clitoris and at a variable distance anterior to the vaginal opening. In children or women with intact hymens the opening may be so close to the vagina as to be almost concealed by the folds of vaginal mucous membrane. The urethral opening usually occurs on a slight eminence, the urethral papilla, produced by the pouting prominence of the lining mucous membrane. It may appear as a sagittal cleft with serrated lateral lips, or as a stellate or triangular opening, due to the longitudinal crests into which the mucous membrane is thrown. Quite constantly there is a periurethral duct, SKENE'S duct, opening to either side of the papilla. Frequently these ducts open just at the edge of the orifice and may be visible externally.

Structure. The lumen of the urethra is lined by mucous membrane continuous with that of the bladder above and the vestibule below.

It consists of a mucosa and submucosa or tunica propria. The mucosa is lined by stratified squamous epithelium like that of the vestibule except in the extreme upper part where it usually takes on a transitional character like that of the bladder. In certain individuals there appears near the middle of the canal an area of irregular stratified columnar cells.

Johnson,[33] 1922, dissected, fixed and sectioned an adult female urethra from which he reports stratified columnar cells of from 6 to 8 layers in the upper third, a somewhat thinner stratified columnar in the middle third, and stratified squamous epithelium in the lower third. It seems probable that there is considerable normal variation in the exact character of the mucosal epithelium.

Underneath the mucosa lies the submucosa or tunica propria. It consists of loose areolar tissue containing smooth muscle fibres, elastic fibres and venous spaces, of which the latter are so numerous near the proximal end of the canal as to make the tissue look dark and spongy. Some of the racemose glands are imbedded in this coat and in its deeper parts there are numerous lymph glands. It is in the outer part of the submucosa that the dilated veins form the corpus spongiosum or erectile tissue of the female urethra, corresponding to the corpus cavernosum urethræ of the male. These veins extend somewhat into the muscular layer. When at rest they are stellate in outline and somewhat flattened dorso-ventrally. The most prominent of these is the crista urethralis on its posterior surface. It is the presence of these folds as well as the surrounding soft tissue which makes the lumen so easily distensible.

Glands. There are many small tubular glands and pitted depressions or lacunæ opening into the mucosa. Those in the upper part are few in number and consist of simple unbranched tubular ducts lying close beneath the epithelium and penetrating the submucosa a short distance. They are lined by thick cuboidal epithelium and have very small lumina. They do not appear to have any actively secreting cells. Toward the middle of the urethra they become more numerous and larger with a number of branches, and they penetrate more deeply into the submucosa. Their ducts also have thick epithelial walls and small or no lumina, but the lumina of the branches are larger. These ducts are lined by cuboidal epithelium of from 1 to 3 layers in thickness. In the distal third the glands are still more numerous and more branched. They do not appear to have secreting cells.

Most of the urethral glands are directed bladderward. They are probably the true homologues of that portion of the male prostate above the prostatic utricle, or the prostatic glands arising from the true urethra.

Near the external orifice are two or more larger branched glands lined with stratified columnar epithelium and lying between the longitudinal folds. These are the periurethral glands, probably of urogenital sinus origin, the largest of which are called SKENE's glands. SKENE's glands open one on either side of the urethra near the orifice, their tubules running from 0.5 to 3 cm. posterolaterally into the wall. The remaining periurethral glands usually open by a common duct, the periurethral duct, just inside the urethra or to either side of the orifice in the vestibule. These glands are probably homologues of the male prostatic glands of urogenital sinus origin, that is, those lying below the prostatic utricle.

Figure 1, through the middle third of the urethra, shows the lining epithelium with the mucosa and the few small thick-walled glands in this area with their small lumina. Figure 2 shows the urethral glands.

Muscular coats. Outside the submucosa lies the muscular coat of the urethra consisting of longitudinal and circular layers, and smooth and striated muscle.

The inner longitudinal layer of smooth muscle lies directly on the submucosa. It is a thin coat near the bladder but grows thicker near the orifice where it is fairly well developed. The portion of this muscle on the floor or posterior wall of the urethra has been shown by Wesson,[100] 1920, to be a continuation of Bell's muscle, a part of the trigonal muscle. The remaining portion of the inner longitudinal layer he showed to be continuous with the external longitudinal muscle of the bladder, a few of whose fibres pass down along the anterior aspect of the urethra just beneath the mucosa.

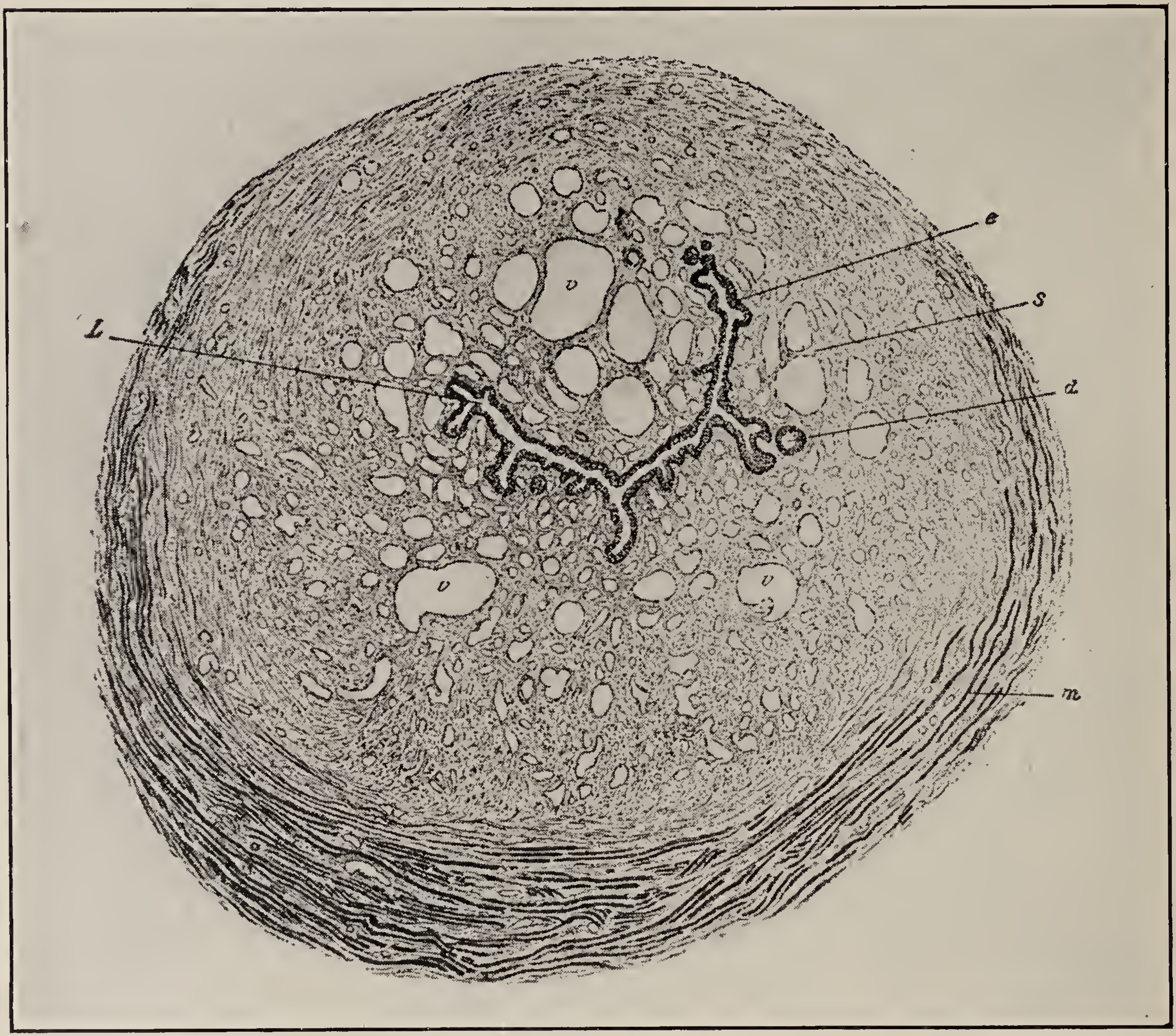

FIG. 1. Cross section through the middle third of the female urethra (after Kolliker).

The outer circular layer is separated from the inner longitudinal layer only by thin connective tissue containing many elastic fibres. This coat, unlike the longitudinal, is thin near the external orifice and well developed around the internal orifice where it forms the involuntary sphincter. According to Wesson this sphincter is not an anatomical entity but is partly continuous with arcuate fibres from the internal circular layer of the bladder and also receives a loop of arcs from the external longitudinal layer.

Below it is continuous with the involuntary circular coat of the urethra with which it is identical in structure. Physiologically it acts as a urethral muscle opposing the action of the detrusor muscle of the bladder.

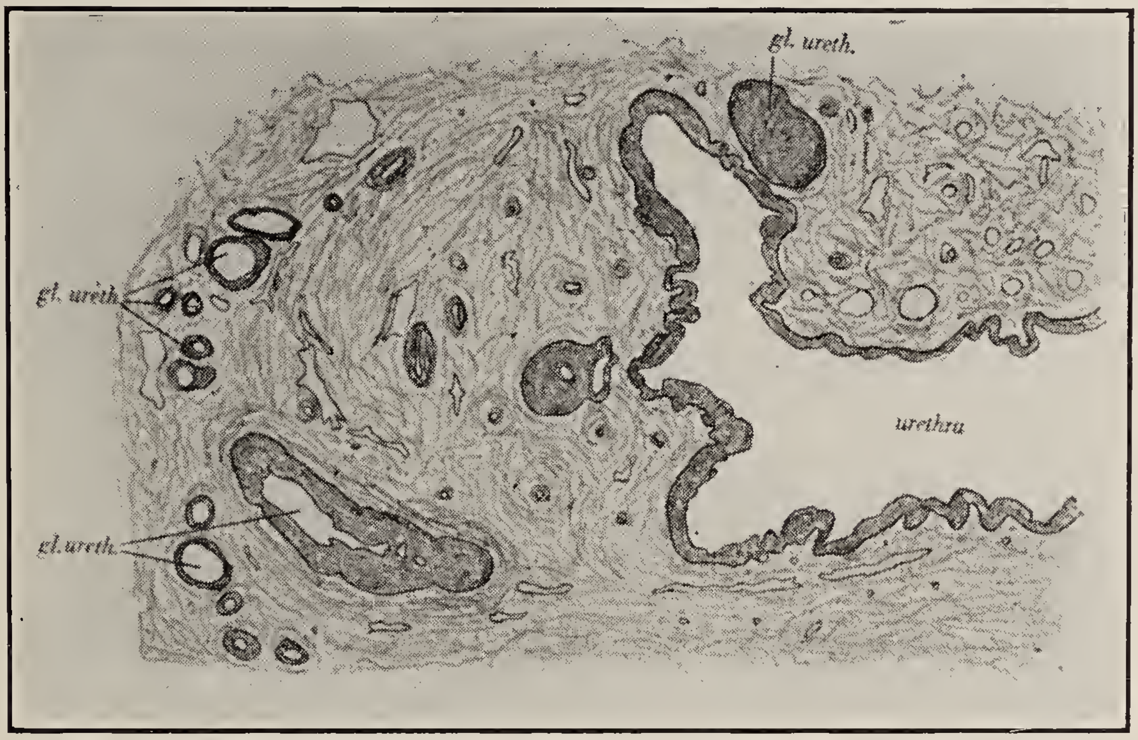

FIG. 2. A portion of the urethra and a few urethral glands of an adult female (after Johnson).

This coat is made up entirely of smooth muscle although some authors classify the voluntary striated fibres as a part of this layer. Kelly and Burnam briefly mention a third thin outer longitudinal layer of involuntary muscle, apparently a few fibres reflected onto the urethra from the circular layer of the bladder.

The outermost layer of the muscular coat is composed of numerous striated muscle fibres lying between the two layers of the triangular ligament. Around the upper free portion of the urethra it forms a complete ringlike sphincter, the external sphincter of the urethra. Below, on the vaginal portion of the urethra, its fibres appear only on the anterior and lateral walls from which they are reflected to their termination in the lateral walls of the vagina. In the extreme lower portion they sweep around the vagina including it and the urethra in the ringlike urogenital sphincter.

The external fibrous coat of the urethra is not well marked and blends imperceptibly into the surrounding tissue.

Vessels, lymphatics, and nerves. The blood supply of the urethra is derived from three sources on each side. The upper part of the urethra is supplied by the inferior vesical branch of the hypogastric artery, the middle portion is supplied by the vaginal branch of the hypogastric, and the extreme lower part is supplied by a branch of the internal pudendal artery, also from the hypogastric. The venous channels are very numerous and freely anastomose with the cavernous veins of the clitoris and bulbi vestibuli. They empty from above and behind into the vesicovaginal plexus, and in front and below into the pudendal plexuses. The blood supply is well demonstrated in Figure 3.

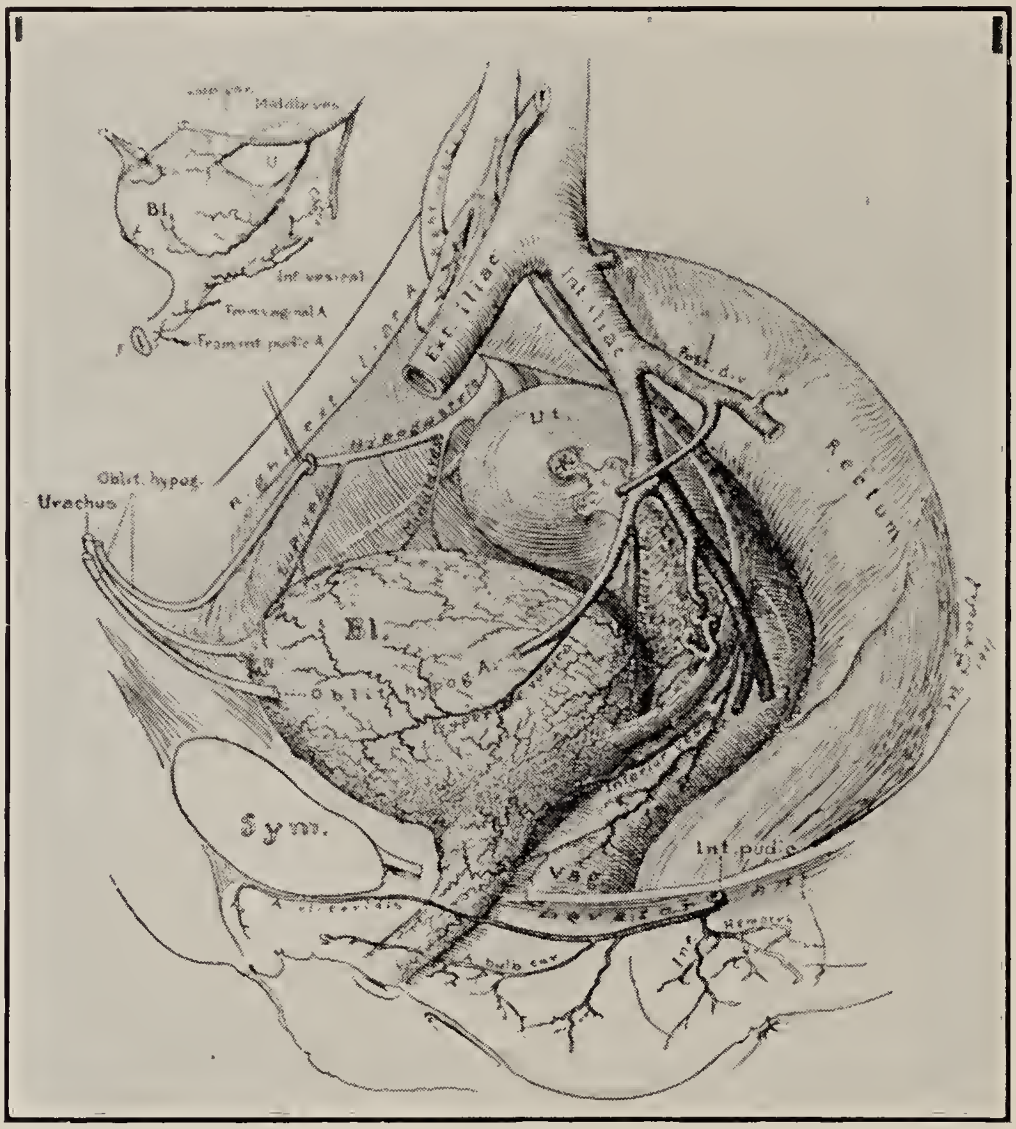

Fig. 3. The arterial circulation of the bladder and urethra as seen from the side (after Kelly and Burnam).

The lymph glands are abundant, especially in the deeper mucosa. They drain upward into the hypogastric nodes and downward into the iliac nodes.

The nerve supply is derived from the sympathetic and spinal nerves. Although the bladder contains parasympathetic fibres, none have been demonstrated in the urethra by anatomical, physiological, or pharmacological methods. The sympathetic fibres arising from the 2nd, 3rd and 4th sacral roots go by the way of the nervi erigentes or pelvic splanchnic nerves to the vesical part of the hypogastric plexus. They form a plexiform network with many ganglion cells in the urethral walls from which they supply the blood vessels and the involuntary muscle coats with afferent and efferent fibres. The spinal nerve supply comes from the pudic nerves which form the pudendal plexus. Many of its sensory fibres end free in the mucosa between the epithelial cells while others have special endings in the tunica propria. Its motor fibres supply the voluntary striated muscle of the urethra.

THE EMBRYOLOGY OF THE FEMALE URETHRA

The development of the female urethra is different from that of the male and somewhat simpler. Perhaps for that reason and because of the comparatively slight attention paid to urology in women, it has been imperfectly described and understood. Most authors of urology have been content to describe it in a few words confined to indicating more or less accurately its difference from the male urethra or its homology with all or part of that organ. Consequently the story of the early development of the urethra before it has become separated from the remaining part of the cloaca and before its manifestation of male and female characters, has been more carefully worked out and described than has its later definitely female development.

Its general homology with the male urethra was recognized long before there was any systematic study of its embryology. In 1853 Virchow first observed that the glands surrounding the female urethra in old women frequently contained concretions similar to those of the male. From this he assumed that the female urethral glands must be homologous to the prostate of the male.

In 1886 Keibel[38] described in detail the division of the cloaca into the urogenital and rectal parts, basing his work on the study of early embryos.

In 1889 Tourneaux[90] made the first embryological observation of the homology of the female urethral glands with the prostate when he described the glands of the adult female urethra as resembling the prostatic glands of a five or six months old male fetus. He observed glands along the whole of the female urethra but found them more numerous distally.

In 1892 Nägel[52] studied the early development of the urethra in male and female embryos. He was the first to define the relation of the urethra to the urogenital sinus as it is now accepted, namely, that the female urethra is homologous only to the true urethra of the male and not to any part of that derived from the urogenital sinus.

Pallin,[57] in 1901, made some observations on the later development of the urethra in which he showed that the female urethral glands were homologous only with the ventral and cranial prostatic glands and not with the lower ones developing from the urogenital sinus.

In 1911 Evatt[20] assumed that the female urethra was homologous with the whole of the male prostatic urethra, basing his conclusions on his model of a three and one-half months old female embryo. His model, however, shows correctly the relations of the female urethra and vagina to the urogenital sinus.

Pohlman,[62] in 1911, wrote a careful description of the cloaca and the cloacal membrane based upon his study of thirty embryos, and included a critical study of the conflicting opinions and observations in the literature up to that time.

Felix[22] in his development of the Urogenital Organs, 1910, has given a detailed and accurate description of the development of the cloaca, urogenital sinus, and vesico-urethral anlage. This remains the most exhaustive and accurate embryological account of the early urethral development and from it is taken much of our data on the early formation of the cloaca and the division of the urethra from it.

Johnson, 1922, has written a careful description of the development of the female urethral glands in the later embryonal and fetal stages. He has been almost the only observer of the later female urethral development, and although chiefly interested in the urethral glands, he has included detailed observations on the anatomy of the urethra and urogenital sinus in each of his stages.

Material for this study of the stages of the female urethral development from a 14.6 mm. embryo to a 60 mm. embryo has been obtained from slides and models of female embryos at the Carnegie Institute, Baltimore, where they were loaned to us through the courtesy of Dr. George Streeter, to whom also we are indebted for numerous suggestions and advice. The length of the embryos studied by us were 14.6 mm., 23 mm., 26 mm., 32 mm., 43 mm. and 60 mm.

In order to understand the anatomy of the female urethra and the exact extent of its homology with the much better known male urethra, as well as to attempt to understand the somewhat rare female congenital anomalies, a review of its development is of value.

THE FORMATION OF THE CLOACA AND ALLANTOIS

The germinal bed from which the body of the embryo is derived consists of an oval germ disk about one millimeter long made up of those portions of the amniotic and yolk sac vesicles that come in contact. Thus, at first it consists of two layers, namely, ectoderm derived from the amniotic vesicle, and entoderm derived from the yolk sac. Later a third layer becomes interposed between them being derived from a proliferative area of the ectoderm, designated the primitive streak. This third layer is the so-called mesoblast or mesoderm. From it and from the primitive mesoderm inclosing the amniotic and yolk sac vesicles there is formed a body stalk which serves to attach the two vesicles to the chorionic wall. It is this body stalk that eventually forms the essential part of the umbilical cord.

As the germ disk elongates the underlying entoderm becomes differentiated into the gut walls. At first the entoderm forms anterior and posterior pockets known as the foregut and hindgut, but even before these pockets make their appearance a tubular ductlike diverticulum of entoderm can be seen extending from the yolk sac into the body stalk at the posterior end of the germ disk. This is the allantois, a structure playing a larger part in the development of lower forms than it does in man.

As the foregut and hindgut form, the latter can be seen as a pocket from that portion of the yolk sac into which the allantois opens. Thus the allantois comes to open into the hindgut. The portion of the hindgut caudal to the opening of the allantois is known as the cloaca. It is this shallow triangular entodermal sack opening cephalically into the endgut and into the allantois which runs off from it at right angles, that is the anlage from which the urethra, by a series of intricate steps, is finally separated and developed. See Figure 4.

The primitive cloaca is limited ventrally by the cloacal membrane, a thin plate consisting of ectoderm and entoderm, formed by the fusion of the entodermal cloaca with the ectoderm of the body wall, perhaps by the carrying forward of the primitive streak during the formation of the tailfold. The mesodermal layer is in some way pushed aside or absorbed from this area, leaving only two layers in the thin cloacal membrane. Keibel's 4.2 mm. embryo shows this membrane beginning cephalically at the point where the allantois opens into the cloaca, as do two early embryos diagrammed by Felix. Pohlman, however, believes this condition to be an anomaly probably occurring only in embryos which, if allowed to develop, would have extrophy of the bladder. He suggests that in such cases the cloacal membrane in this region separates the mesodermal or muscular and connective tissue elements of the anterior abdominal wall and later the thin membrane breaks down producing the anomaly of extrophy of the bladder. He believes the normal cloacal membrane never extends to the dermal navel but only to the Wolffian orifices. Felix assumes the dermal navel to be the normal cranial limit of the early cloacal membrane which with the growth of the embryo becomes pushed back by the growing in of the anterior abdominal wall between the umbilicus and the membrane. In larger embryos the cloacal membrane forms only the caudal portion of the anterior cloacal wall, as is seen in Fig. 5 and Fig. 6. This cloacal membrane remains intact and closes the cloaca to the outside until after it is completely divided.

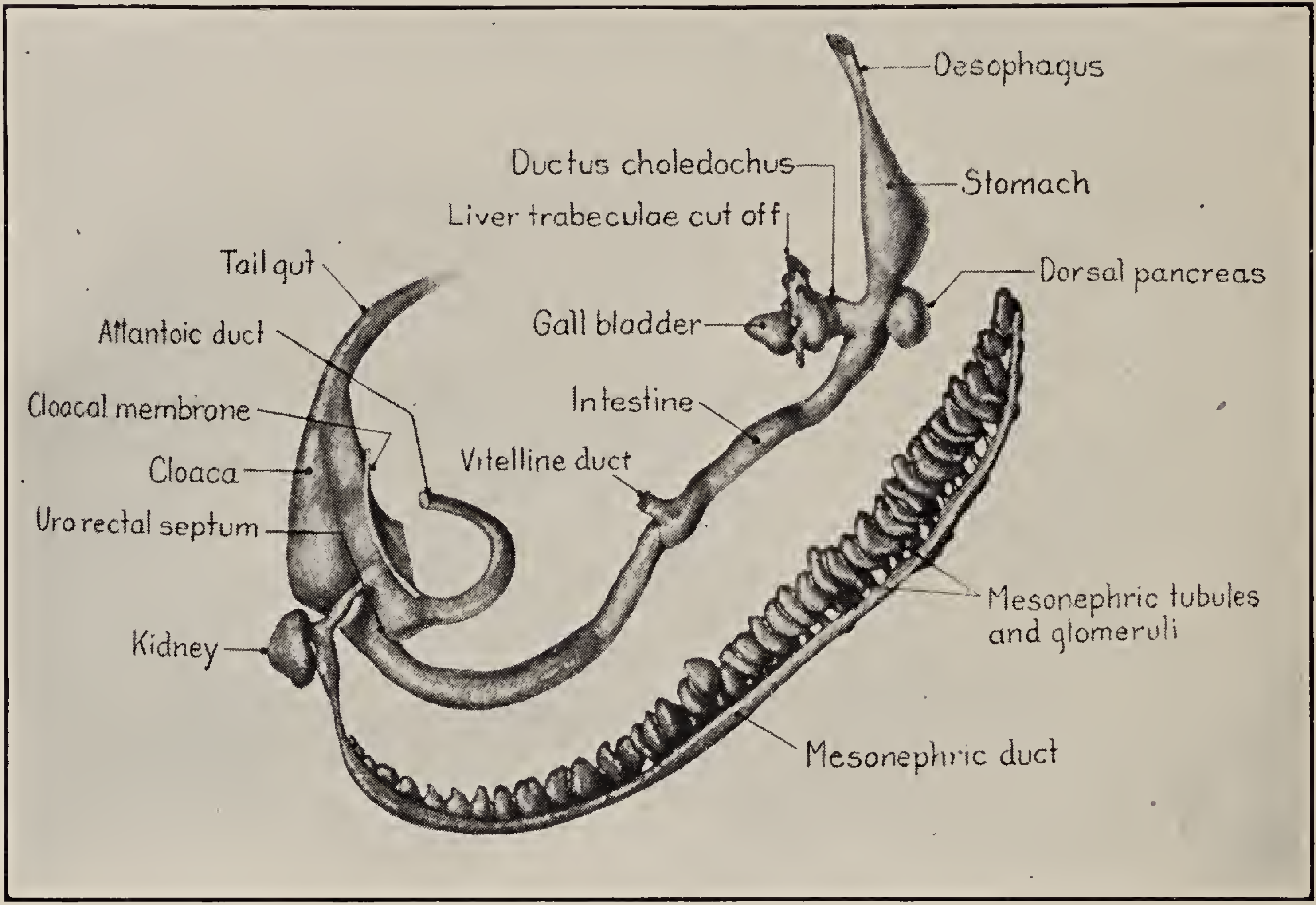

FIG. 4. Geometric projection from a reconstruction model of a 5.5-mm. embryo (after Shikanimi).

THE DIVISION OF THE CLOACA BY THE UROREGTAL SEPTUM

The first division of the cloaca is a longitudinal one in the frontal plane. In embryos of 5 or 6 mm. the " saddle " separating the allantois from the intestine, indicated in Fig. 4, grows slowly downward as a coronal septum. As it advances it separates the cloaca into a smaller posterior rectal portion connected with the tailgut and endgut, and an anterior urogenital portion connected with the allantois. This division normally continues until the urorectal septum meets and fuses with the cloacal membrane, dividing it into the anal membrane posteriorly and the urogenital membrane anteriorly. In certain embryos this downgrowth may be inhibited before it is completed, leaving a portion of undivided primitive cloaca, the cloacal duct of Reichel, connecting the urethra and the rectum. This division is usually complete in embryos of from 12 to 18

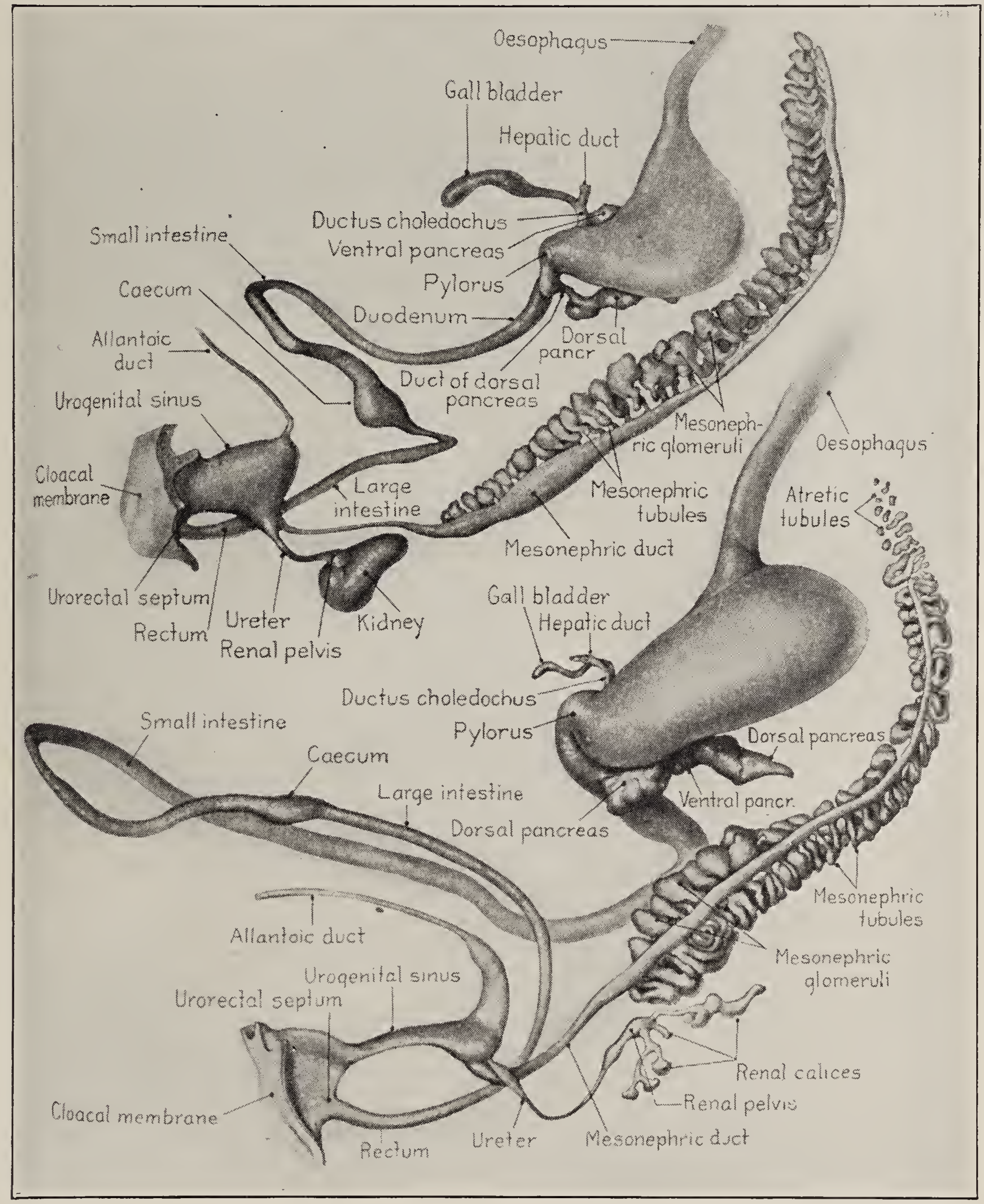

FIG. 5. Geometric projection from a reconstruction model of an 8-mm. embryo. (after Shikanimi).

FIG. 6. Geometric projection from a reconstruction model of an 14.6-mm. human embryo (after Shikanimi).

mm. Figures 5 and 6 show the urorectal septum partly dividing the cloaca. Fig. 6 of a 14.6 mm. embryo shows the division almost complete with only the narrow cloacal duct remaining. Fig. 7 of the 23.6 mm. embryo shows the division completed.

Before this division begins, or at about the time of its beginning, the primary excretory or Wolffian ducts, formed from the extension of the pronephric and mesonephric tubules, have reached and fused with the ventral portion of the cloaca. These ducts grow down as solid cords and reach the cloaca in embryos of from 3.5 to 4.5 mm. At 7 mm. Felix found them penetrating the cloaca, while Wesson found one Wolffian duct entering the cloaca in a 3.9 mm. embryo. These ducts terminate just caudal to the middle of the cloacal membrane and at the junction of the middle and lower thirds of the cloacal cavity. Fig. 4 of a 5.5 mm. embryo shows them entering at this point. The completion of the cloacal division thus leaves them opening into the anterior urogenital portion and the coincident growth of the urogenital sinus gives them an opening on its dorsal surface, as seen in Fig. 6 of the 14.6 mm. embryo.

It is from these primary excretory ducts that the ureters arise, beginning as small blind buds from the dorsal sides of their medial surfaces. They arise at the enlarged lumina of the ducts just as they swing medialward before entering the cloaca growing dorsally and cephalically from their origins until they reach their permanent kidney anlage on the dorsal body wall. Wesson found a ureter bud first in a 6 mm. embryo. Fig. 4 shows one just beginning in a 5.5 mm. embryo. The ureters attain their final orifices in the anterior cloacal remains by the gradual absorption of the terminal portions of the primary excretory ducts into the cloacal wall. After this absorption is completed the orifices are at first situated immediately lateral to those of the Wolffian ducts. Then, due to the growth of the cloacal wall or to the further absorption of the ureteral walls (Wesson), they move laterally and later cephalically to a position about in the adult relationship with the Müllerian hillock remaining at the site of the entrance of the Wolffian ducts. This absorption of the lower ends of the Wolffian ducts increases the size of the cloaca in this region and gives it its " Cloacal horn " shape. See Fig. 5. It also introduces a mesodermal element into the future vesico-urethral anlage.

The Fig. 6 of the 14.6 mm. embryo illustrates the cloacal development at this stage, in which the coronal division of the cloaca is seen to be almost completed, the Wolffian ducts have entered the cloaca and moved to the dorsal surface in about their final positions, and the ureteral orifices have moved laterally from their original position adjoining the Wolffian orifices and have just perceptibly begun their cephalic movement.

OBSERVATIONS OF A 14.6 MM. EMBRYO

The 14.6 mm. embryo shown in Fig. 6 was studied from the reconstruction by Shikanimi,[75] and from coronal sections, Carnegie collection No. 1173, 40 micra thick.

In this embryo the degenerated allantois is shown extending into the body stalk portion of the umbilical cord and running into the upper part of the anterior cloacal remains. The cloaca is almost completely divided coronally by the downgrowth of the urorectal septum, only a narrow strip remaining, the cloacal duct, which may be seen to open into the rectum posteriorly and the urogenital sinus anteriorly. The cloacal plate still exists with no division or opening although the anal groove is indicated by a slight depression on its posterior surface. The cloacal tubercle has appeared but from its form cannot be called either male or female.* The anterior division of the cloaca is flattened dorsoventrally and has already begun to show its differentiation into bladder, urethra and urogenital sinus. It is quadrangular on section and is wider above the Wolffian and ureteral orifices, becoming narrower both laterally and anteroposteriorly below them. The Wolffian ducts enter on the dorsal surface and lateral to them, and about 40 micra cephalically the ureters open. The upper ends of the ureters in this embryo have reached the mesodermal metanephric bud and have already widened to form the renal pelves with a few knoblike branches destined to form the renal calyces.

DIVISION OF THE CLOACAL MEMBRANE

The division of the cloaca, which is normally complete in embryos of from 13 to 18 mm., results in a division of the cloacal membrane into the anterior urogenital membrane and the posterior anal membrane, brought about by the fusion of the urorectal septum with the cloacal membrane. These membranes normally rupture to the outside almost immediately upon their formation, furnishing both rectum and urogenital sinus with an external opening; the anal orifice and the primary urogenital orifice. These membranes have been formed and are open to the outside in the 23 mm. embryo.

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* Spaulding, M. H. "The development of the external Genitals in the human embryo," — Cont. to embryology XIII: 67–88 Carnegie Inst., Washington, 1921.

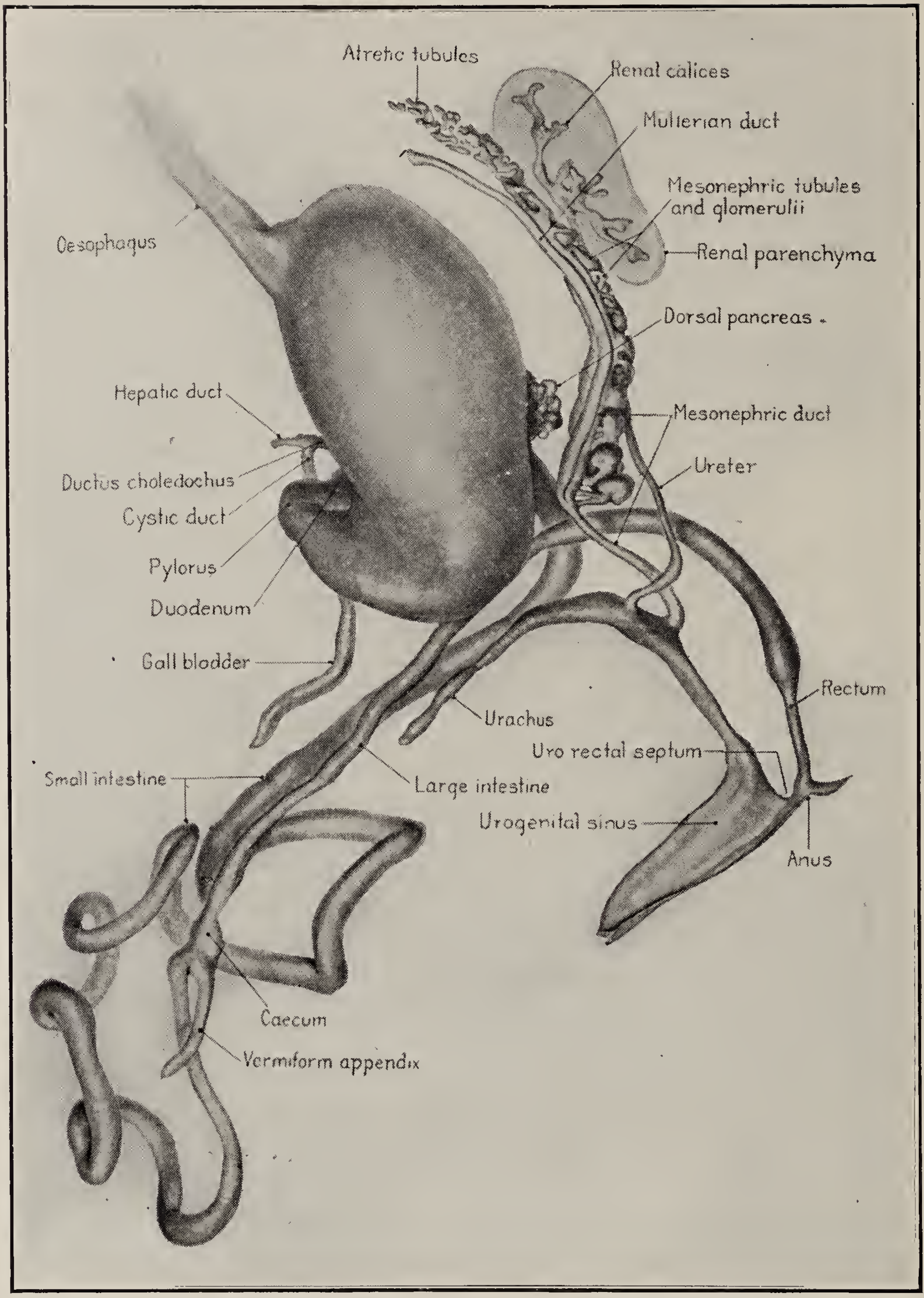

FIG. 7. Geometric projection from a reconstruction model of a 23-mm. embryo (after Shikanimi).

OBSERVATIONS

The 23 mm. embryo shown in Fig. 7 was studied from the reconstruction by Shikanimi, and from coronal sections, Carnegie Collection No. 966 cut 100 micra thick.

This is a considerably more advanced stage than the preceding one with cloacal division complete and both anus and urogenital sinus open to the outside. The primitive urogenital opening is narrow and lies at the caudal end of a groove which extends forward to about the area destined to become the glans. The phallus has appeared and the genital tubercle is marked. The anterior urogenital division of the cloaca is flattened dorsoventrally and shows clearly the beginning differentiation into bladder, urethra, and urogenital sinus. It is widened laterally above the ureteral and Wolffian orifices to about twice the size of the sinus below them. Müller's hillock is a definite eminence between the orifices of the Wolffian ducts projecting into the sinus lumen. The Wolffian ducts enter the sinus as in the 14.6 mm. embryo. The ureteral orifices have now completed their cranio-lateral migration assuming approximately their adult relation to each other and to Müller's hillock, forming with it an almost equilateral triangle. The ureters have formed more or less definite renal pelves at their cephalic ends with calyces nearing their adult form.

In this embryo the Müllerian ducts are seen as narrow tubes with slightly dilated ends arising in the mesodermal tissue lateral to the upper ends of the Wolffian ducts along whose surfaces they run caudally to the level of the lower end of the mesonephros. Here they end blindly in the tissue near the Wolffian ducts, at this stage not having reached each other or their destination in the dorsal wall of the urogenital sinus.

Cross sections of a 26.3 mm. male embryo, Carnegie Collection No. 3681, show the Müllerian ducts lying lateral to the Wolffian ducts in the upper part of their course, then crossing them anteriorly to their medial surfaces with the approach and union of the genital folds to form the genital cord, in which they descend side by side as far as their horizontal bend. Here they separate again and run horizontally forward as two separate ducts to approach Müller's hillock. Thus at this stage their external union is not yet complete and the ducts retain their separate lumina throughout their course.

Cross section of a 32 mm. female embryo, Carnegie collection No. 417, 100 micra thick, show the fusion of the Müllerian tubes complete with a single lumen in the descent through the genital cord and running horizontally forward to Müller's hillock. The blind end of the single duct has not entered the sinus epithelium.

In a 43 mm. female embryo, cut in coronal sections of 100 micra, Carnegie collection No. 886, the utero-vaginal canal formed from the fused Müllerian ducts, is much enlarged but has not yet entered the sinus epithelium. Müller's hillock is more prominent. The bladder is much larger and flattened anteroposteriorly. The urethra is definitely narrower.

The primary urogenital orifice is widened anteroposteriorly and opens at the base of the glans. The glans is formed and has the analward bend described by Spaulding as a female characteristic. The glandar lamellæ destined to form the prepuce of the clitoris, are present.

Sagittal sections of a 60 mm. female embryo, C.C. No. 709, 200 micra thick, first show the uterovaginal canal entering the sinus. The canal, much enlarged, parallels the lower part of the bladder and urethra dorsally entering the sinus opposite the entrance of the urethra. The bladder is large and much flattened dorsoventrally. The urethra is narrow. The sinus remains long and narrow but the primary urogenital orifice is markedly widened.

DIVISION OF THE ANTERIOR PART OF THE CLOACA INTO BLADDER, URETHRA, AND UROGENITAL SINUS

Before the frontal division of the cloaca by the urorectal septum is completed, a second division of the anterior remains of the cloaca is well marked. This division, which separates the bladder, urethra, and urogenital sinus, is a gradual one beginning to show definite progress in an 8 mm. embryo.

The cloaca is anchored to the body wall of the embryo at three more or less fixed points: to the umbilical stalk by the allantois; to the anterior abdominal wall by the cloacal membrane, and to the posterior body wall by the primary excretory ducts. The mechanical effects of the growth and change of shape of the embryo exerting pull at the fixed points of the cloaca, together with the uneven growth of the cloaca itself, determine the final relative size and shape of the bladder, urethra and urogenital sinus. This division described by Felix, is well illustrated in the series of embryos and models studied by us from the Carnegie collection, Carnegie Institute, Baltimore.

At first the anterior cloaca has only a dorsal and ventral wall, as is shown diagrammatically in Fig. 8 *a*. Then, as the cloacal membrane is pushed back from the umbilicus by the growing in of the anterior abdominal wall, a corresponding area of cloacal wall grows in forming the new cephalic wall, Fig. 8 *b* and *b'*, while the original ventral wall, the cloacal membrane, comes to lie on the anal surface of the cloacal tubercle. The curving forward of the caudal end of the body of the embryo at the same time deepens the anterior posterior diameter of the embryo causing the primary excretory ducts and ureters, after lengthening somewhat, to draw out the dorsal part of the cloacal wall in the region of the cloacal horns, Fig. 8 *b* and *b'*, so that the original dorsal wall in Fig. 8 *a* gives place to the new posterior and caudal walls divided by the primary excretory ducts and ureteral orifices, Fig. 8 *b* and *c*. The anterior cloaca is now seen to be quadrangular in section from a lateral view. The 8 mm. and 14.6 mm. embryo, Fig. 8 *b′* and *C′*, show the depression in the cranial wall dividing the lumen of the anterior cloacal remains into three parts; a dorsal wide portion, a median narrow portion, and a ventral wide portion. The two

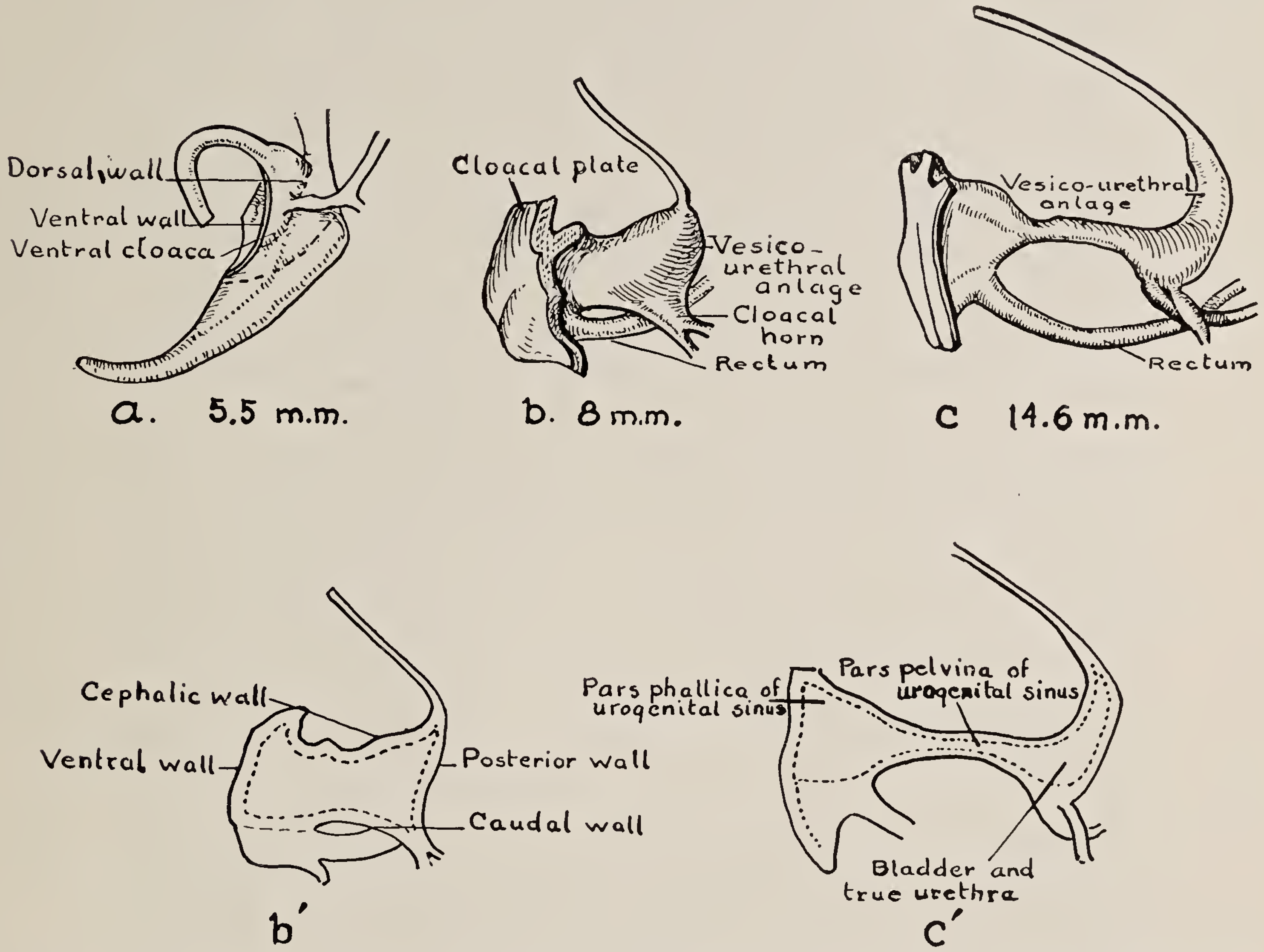

FIG. 8. Diagrams *a*, *b* and *c* of a 5.5-mm. an 8-mm. and a 14.6-mm. embryo with *b′* and *c′*, showing diagrammatic lumina of urogenital sinuses of *b* and *c* respectively.

latter are the pars pelvina and pars phallica of the urogenital sinus destined to become the urethra in the male and the vestibule in the female. The dorsal wide portion, above the Wolffian orifices, is to become the bladder, the bladder trigone, and the true urethra.

The model of the 23 mm. embryo, Fig. 7, shows further change in shape in the broadening of the upper part of the vesicourethral anlage in the frontal plane and narrowing in the sagittal plane so that the anterior posterior walls are almost in contact. This broadening is chiefly due to the absorption of the walls of the terminal pieces of the primary excretory ducts and possibly also of the lower ends of the ureters in the area of the dorsal horns, Fig. 8 *b*. Fig. 9 is a cross section of the same embryo cut at the line *ab* in the preceding figure through the junction of bladder and urethra and shows the beginning separation of the two. The proximal section shows only bladder while that distal shows only urethra.

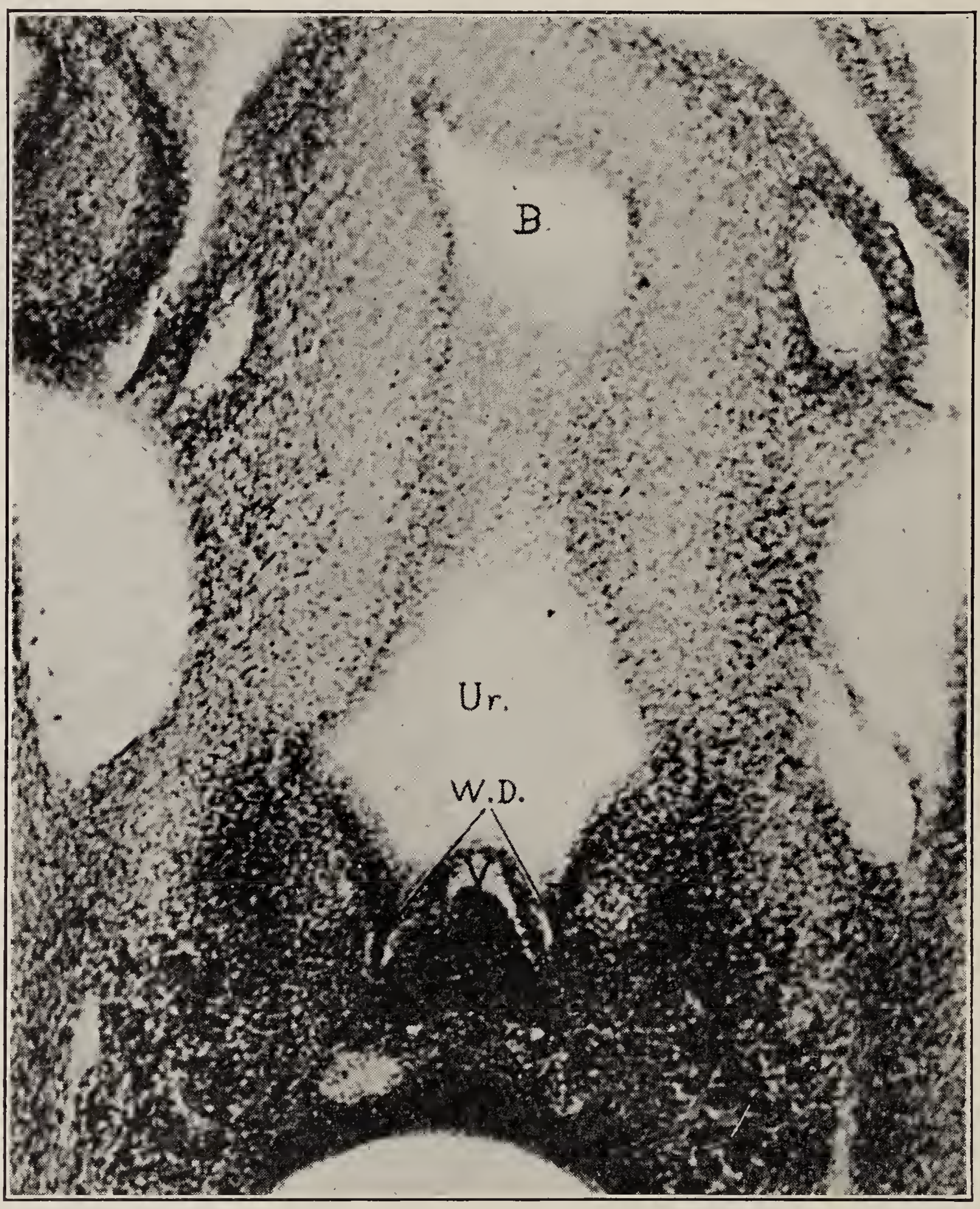

Fig. 9. Cross section of a 23.6-mm. embryo showing beginning separation between urethra and bladder (after Wesson).

Cross section of embryo, Carnegie Collection No. 886, slide 41, of a 43 mm. embryo is cut at a corresponding point and shows the separation of bladder and urethra at a more advanced stage. The bladder here is larger and the urethra just above the entrance of the Wolffian ducts is narrower.

SEPARATION OF BLADDER AND URETHRA

The separation of bladder and urethra is then gradually brought about by the continued enlargement of the bladder while the urethra remains narrow, Fig. 9, and by changes in the epithelium of the urethral wall. At first the entire vesico-urethral anlage is lined by a single layer of cylindrical epithelium with a vesicular character, that is, the cells are light staining with the nuclei lying near the outer portions of the cells. The epithelium of the upper part then becomes two or three layered while that below the ureteral orifices becomes four or five layered. As a result of the rapid cell division of the cells of the urethral portion in forming new layers these cells are smaller with the nuclei relatively large in proportion to the cell bodies, giving them a darker appearance than those of the bladder. The superficial layer then becomes cubical instead of high cylindrical as in the bladder. The cells of Müller's hillock remain for a long time like those of the bladder; one layered, high cylindrical with the nuclei close to the free surface. These epithelial changes, described by Felix, are well seen in the slides of the 14.6, 23 and 32 mm. embryos, C. C. Nos. 1173, 1909, 966 and 417.

MANIFESTATION OF MALE AND FEMALE CHARACTERS IN THE URETHRAL DEVELOPMENT

Until about the 30 mm. stage, the stories of the development of the male and female urethra are almost identical with each other and with that of the bladder. From this point they follow a widely separate course leading to their very different adult male and female characters.

In a 30 mm. embryo the Wolffian ducts in the female have usually begun to degenerate while in the male they continue to grow, forming the vasa deferentia. At about the same stage the Müllerian ducts begin to degenerate in the male, leaving only the remains of the horizontal portion as the vagina masculina or the sinus prostaticus at the colliculus seminalis, the remains of Müller's hillock. In the female the Müllerian ducts develop into the uterus and vagina which for a long time open into a closed tube, the urogenital sinus, opposite the opening of the urethra. The remains of the degenerated Wolffian ducts in the female become the rudimentary canal of Gärtner.

The portion of the anterior remains of the cloaca above the orifices of the Wolffian and Müllerian ducts is now the vesico-urethral anlage, becoming bladder and urethra in the female; and in the male becoming bladder and true urethra, or that portion of the urethra above the colliculus seminalis. The portion below the openings of these ducts is the urogenital sinus, becoming in the male the urethra below the colliculus seminalis, and in the female, by a series of changes, becoming broadened out to form the shallow vestibule between the labia minora.

From this stage the urogenital sinus of the male grows longer and narrower with its small definitive opening remaining at the tip of the glans.

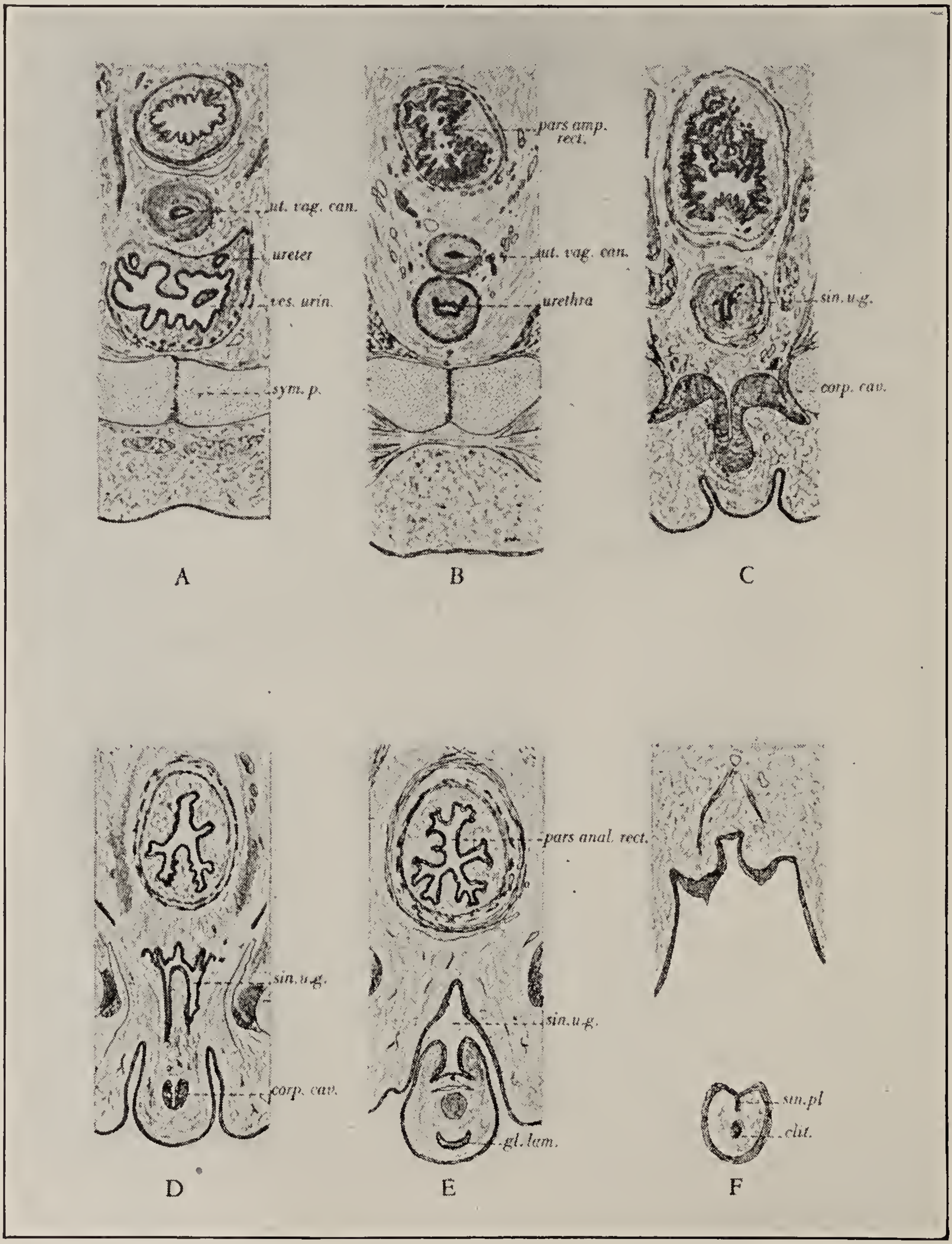

FIG 10. Six successive transverse sections of a female embryo of 75-mm. 12 diam. (after Johnson).

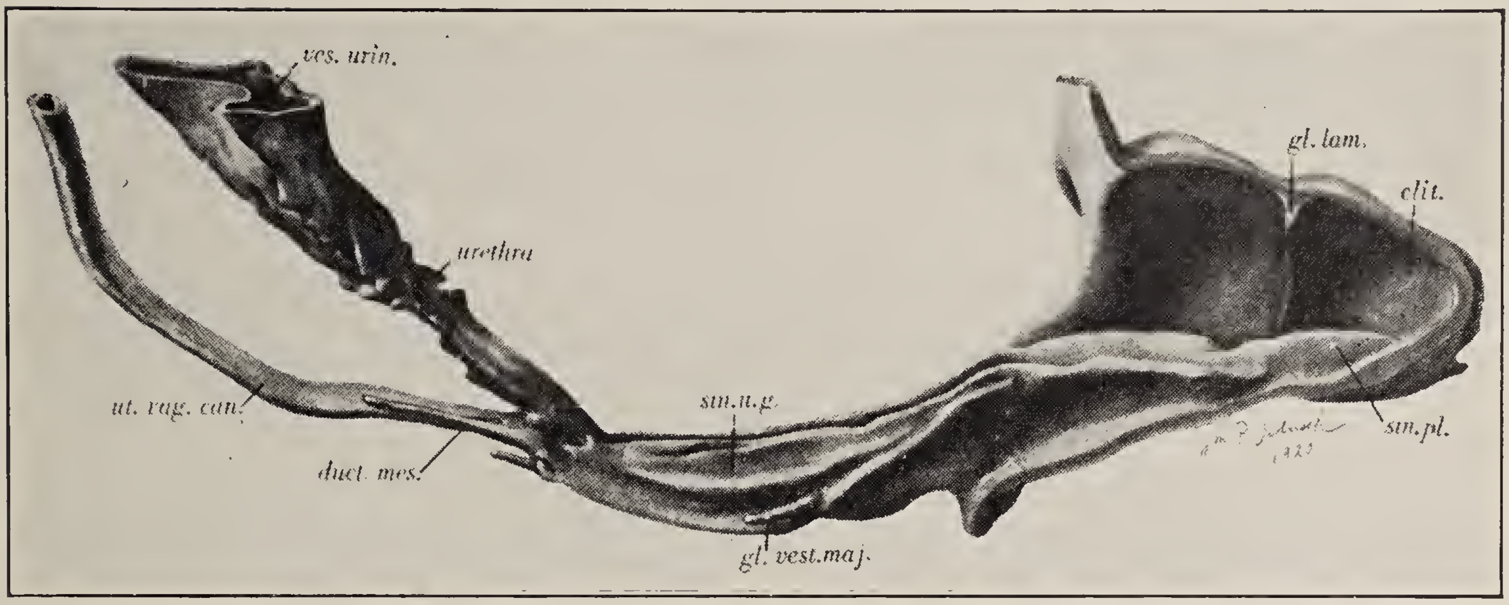

FIG. 11. Lateral view of a wax reconstruction of the urethra, uterovaginal canal and urogenital sinus of a female embryo of 75 mm (after Johnson).

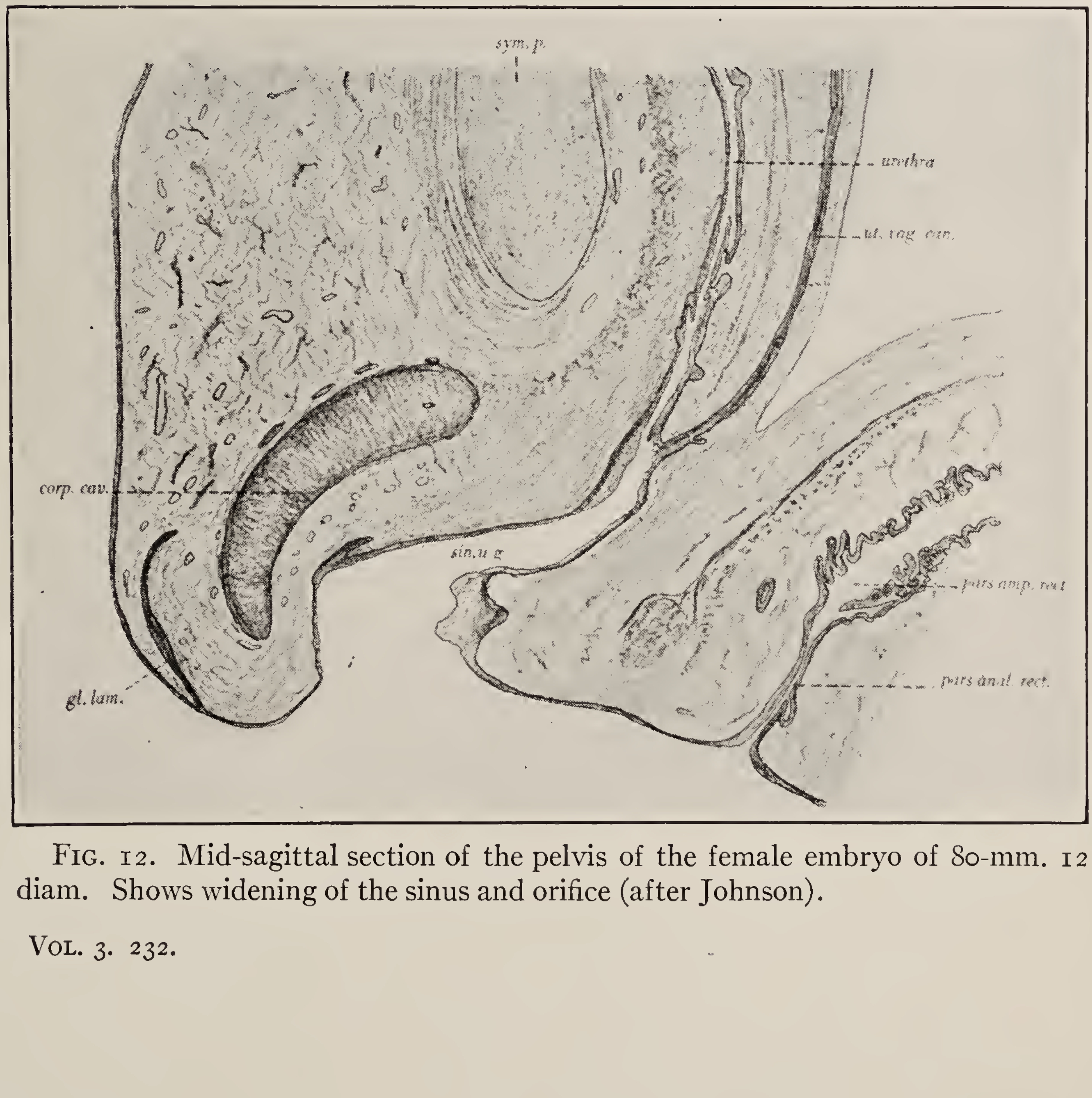

FIG. 12. Mid-sagittal section of the pelvis of the female embryo of 80-mm. 12 diam. Shows widening of the sinus and orifice (after Johnson).

The female urogenital sinus, on the other hand, grows gradually shorter and broader dorsoventrally with a wider orifice until it becomes the shallow vestibule of the adult into which urethra and vagina open. The female urethra at the same time becomes much longer and wider than its homologue, the true urethra of the male.

Later development of the female urethra. The stages of this later development have been carefully traced by Johnson through sections, dissections and models from a 60 mm. to 275 mm. stage through seven female embryos.

In his 75 mm. embryo he found the true urethra elongated. The enlarged uterovaginal canal ran parallel to the urethra dorsally and joined it at its entrance to the urogenital sinus. The urogenital sinus was broader and shorter than in the male of a corresponding stage with folds corresponding to those of the male in the region of the verumontanum. The urogenital orifice was elongated, while in the male it was almost a closed tube. Figure 10 shows cross sections through the urethra and sinus at this stage and Figure 11 is a model of the urethra, uterovaginal canal and sinus of the same embryo.

Figure 12 from an 80 mm. embryo, sagittal section, shows clearly the shortened urogenital sinus, the wide open orifice extending from clitoris to perineum, and the uterovaginal canal opening into the sinus at its junction with the urethra.

In his 150 mm. fetus he found the urethra increased markedly in diameter and flattened dorsoventrally with its epithelium thrown into folds corresponding to the primary folds of the male urethra. The uterovaginal canal resembled a vagina and the short broad urogenital sinus was lined with thin stratified squamous epithelium.

Cross sections of his 176 mm. fetus showed in the upper part a large dorsal infolding of the mucous membrane, two large ventral folds and several small lateral folds. More distally the urethra appeared flattened dorsoventrally and the folds became more irregular, until in the extreme lower end there were no regular folds. The epithelium was stratified squamous and was two to four layers thick. The uterovaginal canal approached its adult structure and was seven or eight times the diameter of the urethra. The urogenital sinus had assumed almost its final form, having become a narrow slit-like cavity between the labia minora into which the urethra and vagina opened in about their adult relationships. Thus at 176 mm. the urethra of the female has assumed almost its final form with its lining, folds, definitive opening and muscular walls similar to that described above in the section on anatomy.

Johnson's 215 and 275 mm. fetuses showed chiefly growth changes and development of the urethral glands, the latter of which remain to be described. On this subject, Evatt 1911, Lowsley, 1912, and Johnson, 1920 and 1922 are almost the only observers.

Development of glands of the female urethra. The glands of the female urethra were first noted by Johnson in an embryo of 60 mm. and were found absent by him in a 43 mm. embryo. This is at about the stage noted in the male by Johnson, 55 mm. and Lowsley, 75 mm. Johnson found them distributed along the whole length of the urethra and along the anterior, posterior and lateral walls. At this stage they were solid, rounded, epithelial growths extending out into the mesenchyme and directed toward the bladder. Most of these glands were on the urethra with a few from the proximal end of the urogenital sinus and a very few from the distal end of the uterovaginal canal. These latter apparently degenerated for they were not found in the later stages. In this embryo he also found two blind tubular ducts on the dorsal part of each lateral wall of the urogenital sinus which he called the major vestibular or Bartholin's glands. In the 75 mm. embryo he found five small glands on the dorsal surface of the urogenital sinus which he called the smaller vestibular glands and the homologues of the glands of Littre. In his 150 mm. fetus he found urethral glands along the whole urethra but they were more highly developed in the distal half. These increased in length and developed lumina in ducts and branches. Those in the extreme upper part remained for the most part unbranched. Those in the extreme distal part were also few and smaller. In the 275 mm. fetus he found two large glands just outside the urethral orifice which he thought arose as prostatic glands from the urogential sinus and were the paraurethral ducts of Skene and therefore not true urethral glands.

The female urethral glands of true urethral origin are therefore homologous only to that part of the prostate arising above the prostatic utricle, the true urethra. The remainder of the male prostate arising from the portion of the male urethra derived from the urogenital sinus and lying below the prostatic utricle finds its homologue in the paraurethral or Skene's glands. Bartholin's glands are homologues of Cowper's glands and the minor vestibular glands are homologues of the glands of Littre.

The urethral glands in the female grow more slowly and never reach the development of the male prostatic glands. They are less numerous, and more scattered and less branched with smaller lumina. Their epithelial walls are thicker and show evidence of active secretion. See Fig. 11.

Development of the Muscular Wall of the Urethra. The muscular

* Johnson, 1922.

walls of the urethra are developed from the thickening of the surrounding mesenchyme. This could be clearly seen in the 23 mm. embryo and was well marked in the 32 mm. embryo at which stage anlage for both circular and longitudinal layers could be recognized. These were observed by Lowsley at 45 mm.

PHYSIOLOGY OF THE FEMALE URETHRA

Physiology. The function of the female urethra is, alternately, to convey the urine to the outside from its reservoir in the bladder, and to prevent its escape from the bladder. Unlike the male urethra it has no normal connection with the genital organs or secretions. In performing its function the urethra is not an inactive passageway, but is a sensitive muscular organ, important in retaining and releasing urine. Many of the causes of frequency, incontinence and retention lie in the urethra itself and must be treated there.

The urethral sphincters are the important factors in urine retention. Of these, the internal sphincter at the bladder orifice seems to be the stronger, and the one usually involved. Although often considered a bladder muscle and continuous with the bladder muscle above and the urethral muscle below (see anatomy, above) it was shown by Versari to be morphologically distinct from the circular smooth coat of the bladder. Physiologically it acts with the muscles of the urethra and trigone, and in opposition to these fibres of the detrusor muscle of the bladder. It is constantly in a state of tonic contraction and reflex tone accomplishes retention during sleep. Rehfisch has shown by a series of ingenious experiments that stimulation of this sphincter alone can give complete control over urination, even to starting the stream, and stopping the stream at will. In the female, its paralysis would probably cause incontinence, for the external sphincter in the female is much weaker than in the male. Young has shown that in the male the external sphincter alone can completely control the stream of urine.

The function of the voluntary external sphincter seems to be to enforce the involuntary sphincter when the contraction of the detrusor would otherwise overcome the contraction of the internal sphincter, with ensuing urination. It is weaker in the female than in the male.

Although contraction of the sphincters causes continence and urination follows their relaxation, yet in the normal individual micturition is a complex act, depending on a fine adjustment and interaction between the detrusor muscle of the bladder, and the sphincters of the urethra, under delicate control of the reflex and conscious nervous centers. A constant flow of impulses to nervous centers and back again over sympathetic and spinal nerves is kept up, being sent to keep the tone of the opposing muscles in balance. A brief review of the physiology of micturition and of the relative parts played by bladder and urethra is of advantage in understanding the complexity of symptoms following female urethral pathology, and, on the other hand, urethral symptomatology, following pathology located outside the urethra.

Micturition may be normally a purely reflex act, as in animals and babies, or it may be largely a voluntary act, or an act initiated voluntarily and stopped, or continued either voluntarily or involuntarily. In other words, the conscious center may interfere and assume control at any time of a process which can, nevertheless, proceed entirely reflexly.

The bladder walls are in a constant state of tension maintained by a flow of afferent and efferent reflex impulses. As the urine slowly accumulates the bladder walls expand to accommodate the increased volume. Constant rhythmical contractions in the bladder wall normally occur. The internal sphincter is in a constant state of partial contraction, to keep the orifice closed, preventing the urine, under its usual tension of 15–18 cm. of water, from escaping. This balance of tension and relaxation is kept up by constant flow of afferent impulses and of efferent impulses of inhibition and excitation to the spinal centers and peripheral ganglia over pudic, pelvic, and hypogastric nerves.

As the amount of urine increases, the rhythmical contractions increases, in strength, and afferent impulses to reflex centers and to conscious centers then cause efferent excitation impulses to the detrusor bladder muscle, causing its contraction with a rise in tension to 20–30 cm. of water inside the bladder. At the same time reflex inhibitory impulses via the pelvic nerves cause the internal sphincter to relax, and possibly exciting impulses cause the trigonal muscles to contract, aiding in pulling open the sphincter.

In animals and in children this is probably the usual process. In adults, conscious interference may send excitatory impulses over the pelvic nerves to the sphincter, causing increased contraction, or inhibiting its relaxation, and perhaps motor impulses over the pudics, causing contraction of the voluntary external sphincter. If this occurs the tension of the bladder in a short time is decreased, and the bladder expands further to accommodate the increase in volume. In a little while the desire to micturate appears again. Strong sensory impulses from any part of the body, and especially from associated parts may also cause bladder contractions with the desire for micturition.

If micturition is not inhibited the detrusor muscle of the bladder contracts down, the internal sphincter relaxes, the urethra opens out, while the bladder is emptied. Following this, and owing to the arrival of excitation impulses over the pudic and pelvic nerves, the striated and unstriated muscles of the urethral wall contract, causing the emptying of this canal.

Thus the desire to micturate is closely related to the tension of the bladder and not to the amount of the contents. The tension rises somewhat with the increased volume and is influenced by afferent impulses from the bladder as well as from any other part of the body. It is also under conscious control.

Goltz originated the theory, later widely accepted and somewhat misinterpreted, that distension increased the normal rhythmic movements of the bladder until on the crest of one of the contractions, urine is forced beyond the internal sphincter into the urethra where it irritates the urethral mucous membrane and leads to the sensation of the necessity of evacuation. This scheme, when interpreted to mean that the reflex of micturition is of purely urethral origin, has been disproven by placing a catheter in the urethra, after which urination can still be started. Probably afferent impulses from the bladder and the urethra or either one alone may normally initiate the reflex.

Thus, disturbances of urination may be of bladder or urethral origin or may arise in the pathology surrounding or far removed. Lesions in the central nervous system or spinal cord may have retention or incontinence as their earliest and most disturbing symptom. Spinal cord lesions below the urinary centers in the lumbar and sacral regions produce partial or extreme states of incontinence and retention, sometimes followed by partial recovery. Highly neurotic states may cause frequency, as may strong sensory stimuli from any other seat of pathology.

On the other hand, lesions in the course of the sensitive urethra itself may be the sole cause of a very frequent desire to void. Painful urination in the female, usually thought referable to the kidney or bladder, is often due to urethral pathology. Cases of renal colic have been traced to strictures of the urethra, and have been cured by their dilatation. In such cases the pains are thought to be referred along the lumbar nerves. Any pain referred to the bladder or any other organ supplied by the pelvic or pudic nerves, supplying the urethra, may be due to urethral pathology. Injuries of the urethral musculature by childbirth or other trauma may be the cause of partial or complete incontinence. In all urinary symptoms in women, the urethra should be carefully considered and explored.

Examination of the Female Urethra. More frequently formerly than now, the female urethra was overlooked entirely in an examination of the genital and even the urinary systems. Until recently it has not been known that abnormal conditions in the urethra of the female subject can be responsible for symptoms and complaints in more remote parts of the urinary system, or even outside of this system entirely. There is no complete examination of the urinary tract if the thorough examination of the urethra is omitted. The urethra is now known to be the seat of much trouble, formerly overlooked through omission of the urethral examination.

Of necessity, this urethral examination must be thoroughly and intelligently made. It should begin by a careful inspection of the parts surrounding the external urethral orifice, such as the vaginal orifice, the vagina, and the labia minora. Inflammatory conditions in these structures commonly are the cause of inflammatory disease in the urethra. Primary malignant growths, for example, of the labia minora are known to sometimes invade the urethra. The labia minora should be carefully wiped dry with clean gauze, and closely examined. Look for swelling, discoloration or tumors.

Observe the external orifice of the urethra. Determine if it is dilated, constricted, prolapsed, or if there is a tumor present. Look for the presence of blood or discharges from the meatus. See if there are congenital abnormalities, such as hypospadias or imperforate meatus. Let the inspection be complete.

Palpation is next in order. It is well to palpate the labia minora, and the meatus, noticing any palpable masses, areas of tenderness, or any fibrosis in any of these parts. With the index finger in the vagina, and placed against the anterior vaginal wall, the urethra should be palpated along its entire course. It should be milked from above downward, and the meatus observed for the appearance of any discharge. Feel for any nodules, fistulæ, or points of tenderness. Thus, a urethral stone might be felt, or a sub-urethral abscess detected.

Next, there are instruments to be used, which are a special aid in examination. A cysto-urethroscope such as the McCarthy (Fig. 13) should be used to examine the inside of the urethra. With it examine the openings of Skene's glands, and both the anterior and the posterior urethral walls. Examine up to and including the vesical neck, where papillomatous growths are frequently found, causing much pain in the subject. The urethra may be dilated with water, if so desired during the examination. It is often impossible to detect areas of chronic urethritis in the female without resorting to urethroscopy.

Then, with one finger in the vagina, a hollow, acorn tipped bougie is introduced into the external urethral orifice. As the bougie progresses toward the bladder, any obstruction, stricture, or dilation can be felt by the palpating finger within the vagina, and its location determined. In this manner, fistulæ may be located.

If there be present any discharge in the external urethral orifice, it should be examined both in fresh smear and also by culture when indi-

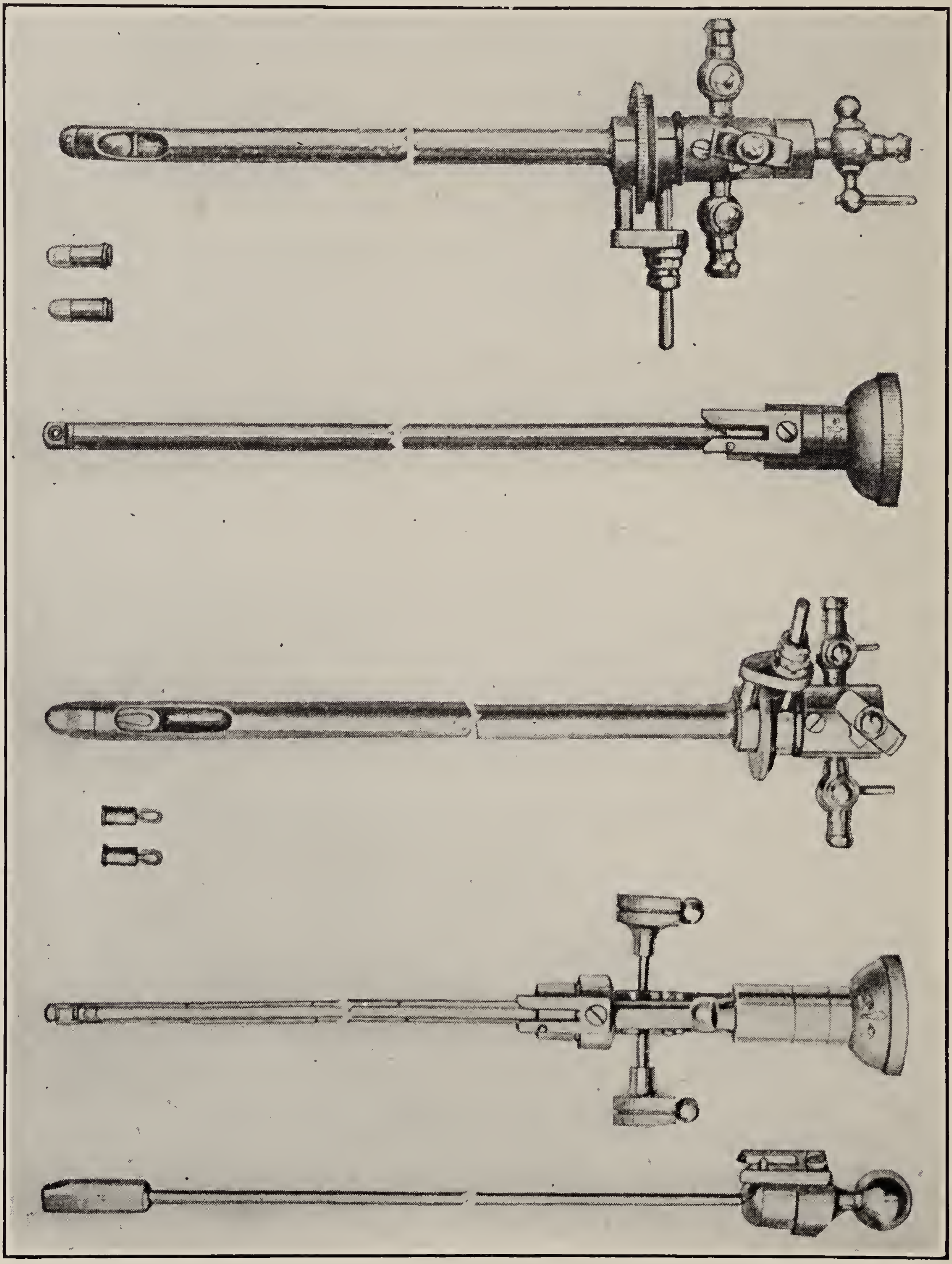

FIG. 13. McCarthy's Cysto-Urethroscope (after Barringer).

cated. In taking this smear a sterile loop should be used to transfer the material to the glass slide for staining and microscopic examination, because if there is only a tiny drop a swab will absorb it and it cannot be transferred to a slide. Culture methods are of particular value in obscure cases of gonorrheal urethritis, as shown by Gradwohl, however, in most locations such cultures are difficult to obtain because of the high cost or lack of facilities.

Of course, it is needless to say that a knowledge of conditions higher up in the urinary tract, e.g., cystitis, or renal tuberculosis, may be of much aid to the operator in diagnosing a kindred condition in the urethra. But in no instance should the careful and painstaking examination of the female urethra be omitted in the examination of the urinary system, and frequently such examination is of importance in examination of the genital system.

CONGENITAL ANOMALIES OF THE FEMALE URETHRA

Congenital anomalies of the female urethra are very rare compared to the number found in the male urethra. This may be explained by the fact that most of the anomalies of the male urethra occur in the penile or transverse portions, while very few occur in the third portion or the true urethra which is homologous to the whole urethra of the female. Those female abnormalities which do occur are usually associated with malformations of the neighboring organs, hence their treatment is often unsatisfactory as to the final outcome. Among the congenital deformities reported have been absence of the urethra, imperforate or partially obstructed urethra, double urethræ, epispadias, hypospadias, and urethral communication with intestine.

Absence of the urethra or complete epispadias. This anomaly is extremely rare and is usually associated in the female with complete absence of the bladder.

Winter[103] (1889) reported a case of a child two years old in which the meatus, vestibule, and labia minora were entirely absent and the ureters opened externally just inside the edge of the imperfectly formed labia majora, being two inches apart. Young reported a case of a girl of eight years with complete epispadias and extrophy. There was no bladder or urethra except as shallow depressions. Petit reported a case of absence of the urethra in which there was a transverse slit in the vagina near the symphysis pubis, this being the opening of the bladder externally (complete hypospadias). The vagina was large and urinary incontinence existed. Kelly and Burnam reported a case of absence of the urethra in which the bladder and urethra ended in a persistent urogenital sinus (see complete hypospadias.)

Imperforate or partially obstructed urethra. This defect may be a true defect of development or may be acquired by adhesions late in intrauterine life. It is usually associated with other embryological defects; as a suprapubic opening, an opening into the vagina or an open urachus. If the defect occurs due to adhesions late in intrauterine life the child may live, but treatment by making an artificial opening must be instituted at once. Brown and Carbielle[9] in studying the urogenital tract in 80 fetuses and young infants reported a case of imperforate urethra with a dilated bladder, urethers, kidneys and abdominal cavity.

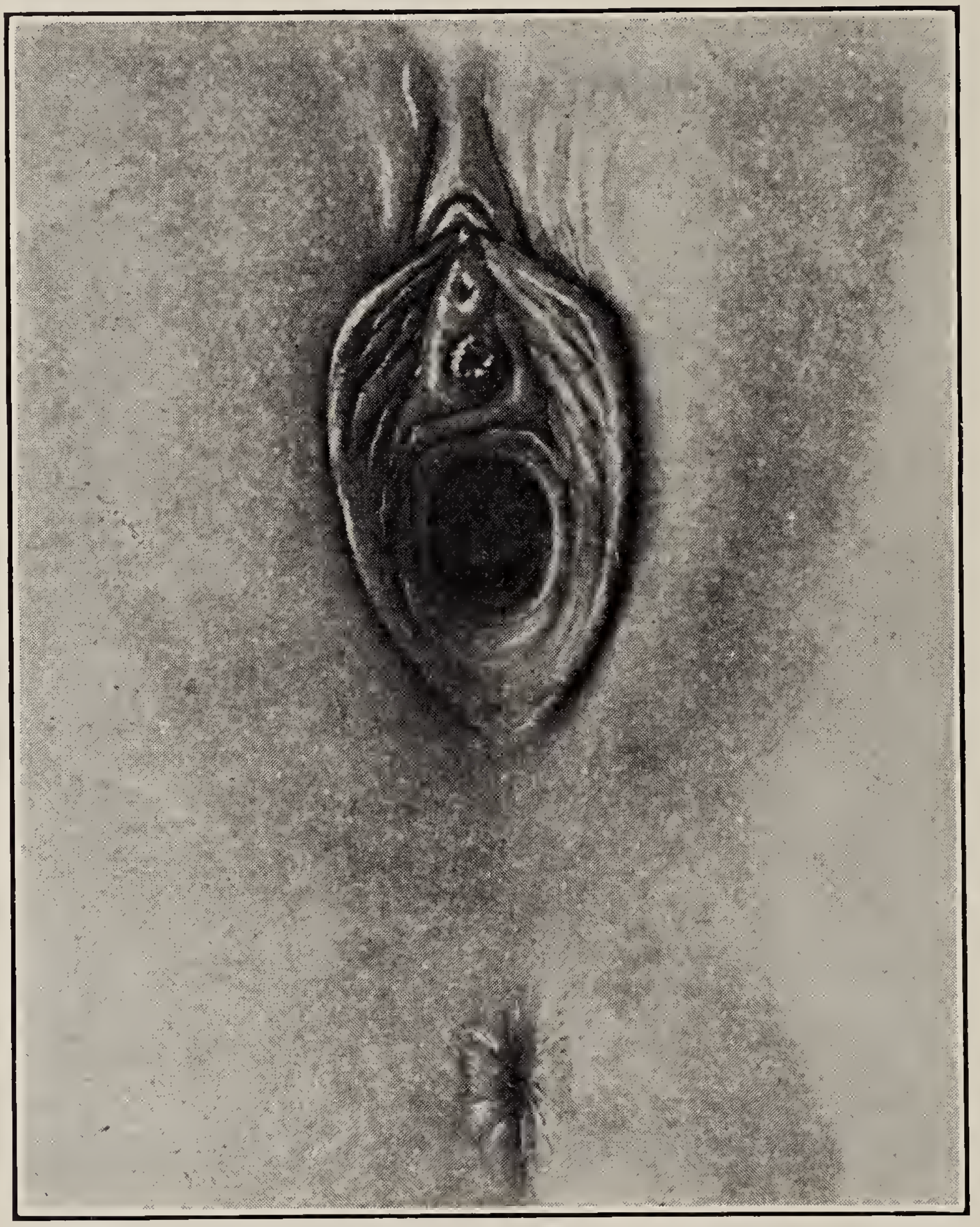

Fig. 14–*a*. Typical caruncle seen on vestibule below normal external urinary meatus (after Dannreuther).

Double urethra. True double urethra in the female is a very rare anomaly. Four have been found by us in the literature, two of which were not thoroughly investigated. Lowsley (1921) had found only one case in the literature which he considered authentic, that of Dannreuther. Since then Kelly and Burnam have reported one case of their own. Dannreuther's case, Mrs. K. H., age 50, was married and never pregnant. Her past and family history were negative and she was in good health up to six months before she was seen by Dannreuther. He says, "The patient complained of increased diurnal frequency of urination, nocturia, and burning sensation on voiding. These symptoms had been present for about six months. At no time during the patient's life had she suffered from enuresis or incontinence." * Aside from the malformations about to be described, the external genitalia and pelvic organs were all normal. "When the labia were separated a small red excrescence was discerned on the vestibule, just below the normal external urinary meatus (Fig. 14 *a.*) It presented the appearance of a caruncle and was exquisitely sensitive. A probe pushed through a tiny slit in its center encountered little resistance and traversed a path upward, backward and to the right (Fig. 14 *b*). When a cystoscope was introduced into the bladder, the probe was seen to emerge from a small aperture in the vesical wall a little to the right and above the right internal orifice (Fig. 14 *c*). A ureteral catheter inserted through the anomalous channel drew urine from the bladder. Subsequent inspection through a small Kelly endoscope disclosed

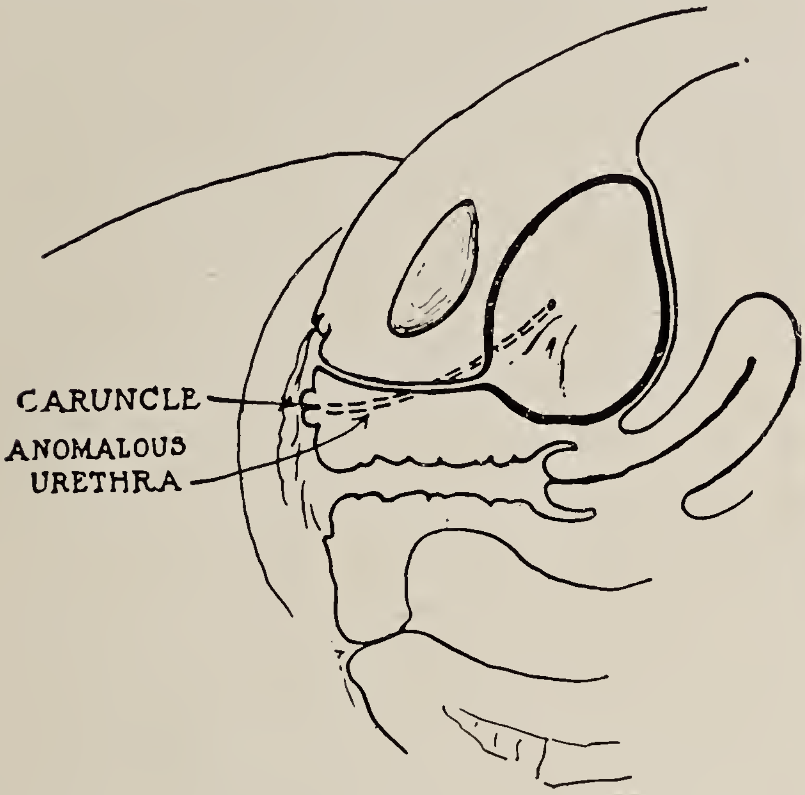

FIG. 14–*b*. Complete double urethra showing course of second complete urethra (after Dannreuther).

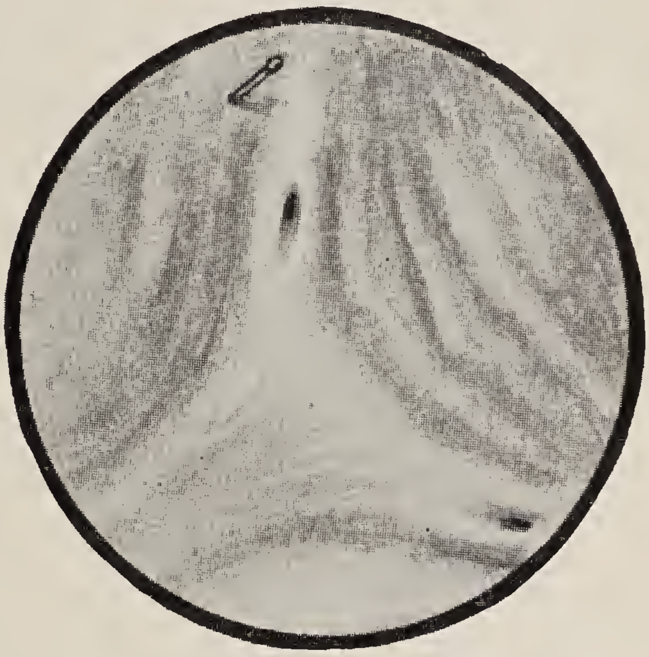

FIG. 14–*c*. Cystoscopic view of probe entering bladder through aperture above and to the right of the true urethral orifice (after Dannreuther).

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* Dannreuther, Walter L.: Complete double urethra in a female J. A. M. A. **81**: 1016; Sept. 22, 1923.

a mucous membrane lining. Removal of the caruncle uncovered a very small vestibular opening and promptly relieved the patient's symptoms.*" The kidneys and ureters were normal. Kelly and Burnam (1922) reported a case of double urethra in which symptoms were relieved by removing one of the urethræ. Fischer[24] cites a case of double urethra reported by Gleiss associated with double bladder, ani, labia majora and vagina in a female child. M. Lewis reported a case seen in 1875 of a woman examined one year following a confinement and complaining of inability to void. In attempting to catheterize he discovered two small openings, one on either side of the vestibule about ½ inch apart. One opening admitted a number 5 catheter through which urine was drawn. The patient stated that after a previous delivery she had been unable to void until after an operation, but no information about it could be obtained because the operating physician had "long been dead." It is of course possible that one of the openings was traumatic although two orifices one to either side of the midline are described.

Epispadias. Epispadias in the female is a defect in the anterior urethral wall. It may be seen with the orifice high, a divided clitoris and the labia minora widely separated anteriorly, varying from a slight defect with none or very slight symptoms up to an extreme deformity with divided symphysis and anterior abdominal wall with complete extrophy and incontinence. Ballantyne[4] (1896) reported 33 cases of epispadias and found annoying incontinence to be practically the only symptom. Lower[45] (1923) found 43 authentic cases in the literature. Lower quotes Durand and Guyon's classification of epispadias:

(1) Separation of the corpora cavernosum of the clitoris, with emergence of the urethra into the dorsum of the clitoris.
(2) Emergence of the urethra into the dorsum of the clitoris showing great defects of its own anterior wall.
(3) Entire absence of the anterior urethral wall, usually associated with a prolapse of the bladder mucous membrane.
(4) A cleft of the anterior abdominal wall, with non-closure of the symphysis, usually associated with prolapse of the bladder mucous membrane.

Kelly and Burnam classified the degrees of epispadias a little differently:

(1) *Clitoridal,* where the clitoris is divided into two halves and the urethra opens just above them.
(2) *Symphyseal,* where the urethra opens directly under the symphysis.

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* Dannreuther, Walter T. Complete Double Urethra in a Female, J. A. M. A., **81:** 1016, September 22, 1923.

(3) *Retro-Symphyseal*, where the defect takes in the whole anterior abdominal wall but does not involve the bladder.

Epispadias has been explained by various theories of abnormal embryological development. Probably it is due to the extension of the cloacal membrane up over the anterior body wall either part or all the way to the stock of the allantois. The thin cloacal membrane made up of only the ectodermal and endodermal elements then splits its whole length leaving a deficient anterior wall of the urethra (partial epispadias) or of the urethra and bladder (extrophy). Whether the cloacal membrane grows up to cover a defect in the anterior body wall, or whether there is a defect because the cloaca has grown forward is in dispute. Felix thought the cloaca normally first reached the stock of the allantois and then was pushed down by the growing in of the anterior abdominal wall, but his evidence has since been severely attacked.

A case classed in the third group of Durand and Guyon's classification is presented below by the kind permission of Dr. Barney Brooks of Vanderbilt University Hospital.

M. E. B., 23 months old, white, female. Admitted to Vanderbilt University Hospital, March 30th, 1927.

Chief complaint: Bleeding, raw mass protruding from between labia majora.

Present illness: Deformity noticed at birth. At the age of one year and 11 months, first symptoms occurred, at which time there was a sudden protrusion between the labia about the size of a thumb. The mass was reduced by holding the child by its feet. Six months later it came down again causing the same symptoms. Anesthesia was necessary for reduction. A month previous to admission the same thing occurred. Two days prior to admission, the mass came down and there was bleeding, pain and incontinence.

Past history: General health good. No infectious disease except whooping cough. Systemic health negative except for G. U. symptoms.

Family history: Irrelevent.

Physical examination: Child well nourished and normal except genitalia.

Genitalia: The labia do not meet in front of the urethra. Symphysis pubis present. Between the anterior part of the labia there is a mass about the size of a hen's egg protruding, bleeding, red and tender. Appears to be covered with bladder mucosa. Extremities normal. Under ether anesthesia mass removed. During the next three days, the edema in the tissues rapidly decreased. On April 5th, 1927, sodium iodide, 4%, was injected into the bladder and cystogram made. Bladder capacity 4 cc. Cystogram shows an incomplete filling of the bladder. There is marked separation of the pubic bones. On April 8th, 1927, plastic operation on urethra was done.

Operation note: The clitoris was excised with a transverse elliptical incision. This transverse incision was extended to the right and left until it met the superior ends of the labia majora. The mucosa of the urethra was then freed from the inferior and posterior aspects of the symphysis pubis. A deep stitch was then placed posterior to symphysis as high as possible. This stitch was then passed through the submucous tissue of the most anterior portion of the urethra. The urethra was then pushed as far posteriorly as possible and the stitch tied. This stitch resulted in the pulling of the most distal portion of the superior wall of the urethra to a point slightly behind the symphysis pubis. The submucous tissues which were exposed were then approximated by repeated layers of fine interrupted catgut sutures. These sutures were placed in such manner as to continuously decrease the size of the external urethral orifice and to draw it posteriorly behind the symphysis. The transverse incision was then closed longitudinally. This resulted in the formation of the anterior wall of the distal portion of the urethra from the mucous membrane-like tissue which previously lay between the superior ends of the labia majora. The principle of the entire operation was, after all, the converse of the Heineke-Mikulicz procedure in that it was an incision which was closed at right angles to its length in order to reduce the lumen rather than to increase it. Patient made an uneventful recovery. Discharged April 15th, 1927. A follow-up letter in July 2, 1927, the baby was having no pain, straining or incontinence. Mother stated she would bring the baby back to the hospital if she had any further symptoms. Patient had not returned at the present date. June 2, 1930, patient's physician interviewed and stated that patient died May 6th, 1930 of Tuberculous meningitis. At the time of death the urinary condition was giving no symptoms."

Treatment of epispadias. Stiles[84] in 1911 successfully transplanted the ureters into the colon with resulting continence of urine. He believed it to be the treatment of choice for epispadias with complete incontinence. His patient was able to retain urine from three to five hours. He quotes Gaebell as having approximated the pyramidal muscles about the neck of the bladder so as to form a sphincter. This sphincter of course was involuntary and the patient was able to sleep without wetting the bed but was unable to keep dry while walking or playing.

Lower thought that most plastic operations accomplished little but that transplantation of ureters into the colon insured relief from incontinence. Gersung reported successful results with torsion of the urethra along its long axis, twisting it through a half turn at three different times. He obtained continence for five hours. Ralph Thompson[89] has devised an ingenious operation for this defect. He brought the rectus muscle down from the right side and around to the orifice of the urethra and vagina. He buried the rectus deeply and anchored it to what he considered the central point in the perineum. One girl held water two and a half hours and he thought she could be trained to use the rectus as a sphincter. For æsthetic and surgical reasons he advised doing this operation at the age of two months. In infancy the bladder is larger and the training for incontinence would be easier. He had performed this operation four times with improvement in each case.

Hypospadias. Hypospadias is a defect in the inferior wall of the urethra with a part of the wall missing and with the orifice on the anterior vaginal wall.

The defect may be slight with no symptoms or there may be a very short inferior wall with a wide opening to the bladder and incontinence. Coitus may then take place into the bladder with a resulting symptom of incontinence appearing only after several years or months of married life due to the gradual widening of the short urethra.

The defect may be explained embryologically as a persistent urogenital sinus, the urethra and vagina still opening into one cavity as is seen in the 75 mm. and 80 mm. embryos, Fig. 11 and Fig. 12, before the urogenital sinus widens out to become the vestibule. Lowsley of New York has kindly furnished data on one of his cases as follows. The author witnessed the operations.

"Miss V. S. Female, age 28, admitted to New York Hospital March 3, 1925.

Family history: Irrelevant.

Personal history: Had usual diseases of childhood.

Menstrual history: Regular, painless, 28-day cycle and four-day duration. Has never been able to control her urine. She does not lose so much urine while sitting except when she would cough, sneeze or laugh heartily. For first week following menstruation she had a little better control. The control while lying down was slightly better, when she slept she never had any control. She had been treated by various physicians with vaginal tampons, catheterization and irrigation and in 1912 she had a vaginal operation for falling of the womb at which time sutures were placed in some location about the urethra with the hopes of relieving incontinence, all to no avail.

Physical examination: Showed patient to be well developed and well nourished female with several red moles of seedy nature resembling an orange peel in appearance in various locations over her body; no palpable glands. Rectal examination was negative. Urethra had no muscular tone as fore finger could be inserted easily into the bladder without meeting resistance.

OPERATION FOR RELIEF OF INCONTINENCE IN WOMEN

Anesthesia: Sacral, parasacral anesthesia was entirely satisfactory for this operation, 1 % procain with adrenalin being the medium employed. Suprapubic bloc was employed for the first operation. The operation was performed in two stages, and both operations were performed at the same sitting. The first operation was a suprapubic cystotomy. Suction with the double tube for bladder drainage was employed so that the urine was kept from passing over the cut surfaces of the operative wound below. A (v) shape section was cut out of the bladder neck at the first operation. There was much bleeding.

The patient made an uneventful recovery and was discharged from the hospital on April 13, 1925, with wound healed and able to control her urine for $2\frac{1}{2}$ hours.

She was readmitted to the hospital, June 8, 1925 as her control had been greatly reduced and the sphincter was somewhat relaxed.

The second operation was performed on June 8, 1925, another suprapubic cystotomy having been performed. The patient was placed in the exaggerated lithotomy position. A semi-circular incision was made around the upper part of the urethral orifice and the entire upper and lateral surfaces of the urethra dissected free from its attachments to the symphysis pubis and surrounding tissues. This dissection was carried back beyond the vesical orifice. The entire roof of the urethra and inverted (v) shaped portion of the vesical orifice were dissected away. The vesical orifice was then sewed tightly over a #10 soft rubber baby catheter, as was also the entire urethra. The latter when repaired was stitched tightly to the periosteum of the under surfaces of the symphysis — the orifice being joined with the cut surfaces of the skin. The catheter was then removed and the patient immediately put on suprapubic suction drainage, upon which she remained for a period of three weeks.

The suprapubic wound was then allowed to heal and the patient passed urine through the proper channel in due time. A little exertion was necessary at first, but control has been excellent with no dribbling. This patient was seen on May 11, 1927 (two years after operation); the entire night is gone through without urination or dribbling and during the day evacuation of the bladder is necessary at intervals varying from two to five hours depending upon the amount of fluids ingested, exposure to cold and other influences which effect the secretion of urine."

A case of extremely large urethra without incontinence was seen by the author in Vanderbilt Hospital in August, 1928.

Case report: Mrs. H. W. T. age 30, bed-ridden with pulmonary tuberculosis complained of frequency and dysuria. She gave a history of having passed several stones some of which were as large as pecans.

Examination revealed three large stones in bladder and a stone 1½ cm. in diameter protruding from right ureter. I was able to remove the stone from the ureter by putting the little finger through the urethra and the fore finger of the other hand into the vagina and manipulating the stone between them. Sponge forceps were inserted through the urethra and attempt made to crush the stones under the flouroscope, but they were too hard and a suprapubic cystotomy had to be done. Insertion of little finger and sponge forceps were painless even though no anesthesia was used.

In the female hypospadias is a fairly rare defect. Kelly and Burnam (1922) quote Blum as having collected 35 cases (1904) dividing them into three classes.

(*a*) The urethra completely divided with a slitlike communication between the bladder and vagina. (11 cases).

(*b*) The vagina imperfectly developed, ending in the urethra, i.e., a persistent urogenital sinus. (14 cases).

(*c*) The urethra ending above the vagina. (10 cases).

Von Mosengell described a case in which the anterior portion of the urethra was represented by a groove running from the normal location of the external orifice to a point deep down behind the vaginal orifice where was found the completely closed orifice of the urethra. The groove-like formation seemed to be due to an absence of the lower wall of the urethra in that part.

The only symptom is incontinence of urine. In slight degrees of the defect there may be no symptoms, or symptoms may develop later in life, notably after marriage.

Congenital diverticula of the urethra. Congenital diverticuli of either male or female urethra are very rare indeed. Most diverticuli are acquired and even those which have been attributed to congenital causes are probably not true congenital abnormalities. Watts found 16 cases, all of them in the male, and only two of these were in the third part of the urethra or the part corresponding embryologically to the female urethra, the part above Müller's hillock. He classified diverticuli as congenital and acquired, and believed practically all were acquired. Priestly,[65] Tait,[85] Routh,[71] Gillette and Bagot[2] have all reported cases of diverticuli in the female, but later authors have all questioned the probability of their being congenital.

Verriotis and Defrise,[94] in their article, Des Diverticules Uretraux chez la Femme, (1926) believed that most of the cases reported as congenital were acquired, and that the diagnostic point must be the presence of the muscular coat like that of the urethra. They believed that the presence of the urethral epithelium was not a test and that it might be present in cysts or diverticuli produced by infection. They quote Josephson as reporting a case probably congenital which he believed to have arisen from the remains of the embryonic duct (canal of Gärtner).

This defect (first described by Bagot in 1895) is one in which there is a cavity or pouch situated in the urethro-vaginal septum, usually about the middle third, communicating by a narrow opening with the urethra, which is not dilated but of normal calibre. The patient may present the symptoms of frequent and painful urination. There may be, and usually is, a discharge of pus from the urethra. There is much ammonia in this pus, and it is very irritating even sometimes to the fingers. A catheter may be frequently passed into the bladder and normal urine obtained even in the presence of diverticuli. The opening of the pouch may usually be seen with the urethroscope, and the tumor which is palpable, may vary much in size, even reaching the size of a hen's egg or larger.

Treatment consists in dissecting out the cystic formation and closing the cut surface with silk or catgut. A retention catheter is inserted and allowed to remain.

Persistent cloacal duct of Reichel. A case was reported in the Johns Hopkins Bulletin (1922) in which the intestine emptied into the urethra, the anus being absent. This seemed to be due to a defective development of the wedge of tissue separating the urethra and rectum which normally forces them apart. This is known embryologically as a persistent duct of Reichel and is caused by the failure of the downgrowth of the urorectal septum. See Fig. 6 of a 14.6 mm. embryo showing the persistent connection between the rectum and the vesico-urethral anlage.

URETHRITIS

History. Urethritis in the female was formerly thought to be a very rare condition but in recent years it has come to be recognized as quite common. Morgagni,[50] in the 18th century, mentioned that in some cases pus passed from the meatus. Sir Henry Thompson[88] thought the condition to be very rare and tried to explain such a rarity on the location and the anatomical structure which protected the urethra in the female. Sir Chas. Bell[5] mentioned gonorrheal urethritis and was the first to connect it with urethral stricture (1811). Van der Warker[92] (1890) in writing on stricture remarks that it is not so much a question of the diameter of the passage as of the freedom of the passage from disease. Winckel[102] made the statement that urethritis is not as important in the female as in the the male, due to the smaller area involved. Such was the opinion of the former authorities but today urethritis in the female is recognized as both frequent and important.

Incidence and etiology. Urethritis occurs at all ages and a great many cases are reported in the literature as well as seen in a urologist's daily practice. It is almost a constant accompaniment of gonorrheal endocervicitis and vaginitis, and the location of the urethra at the lower end of the urinary tract with the frequency of inflammation in the kidney ureter and bladder above it seems to make a favorable place for secondary inflammatory processes.

Bugbee[10] (in 1917) reported 1000 cases of urethritis giving the age incidence by decades and the causes in each decade. His table showing his results follows:

In the first decade,	3	out	of	7	due	to	gonorrhea
In the second decade,	29	"	"	61	"	"	"
	5	"	"	61	"	"	post-operative catheterization
	2	"	"	61	"	"	masturbation
	6	"	"	61	"	"	B. Coli pyelonephritis
	1	"	"	61	"	"	Influenza
	1	"	"	61	"	"	tuberculous kidney
In the third decade,	124	"	"	219			cause not given
	7	"	"	219	due	to	post-operative catheterization
	17	"	"	219	"	"	B. Coli pyelonephritis
	2	"	"	219	"	"	" " " (in pregnancy)
	2	"	"	219	"	"	syphilis of kidney
	3	"	"	219	"	"	nephritis
	6	"	"	219	"	"	associated stricture
	9	"	"	219	"	"	tuberculous kidney
	3	"	"	219	"	"	cystocele
	1	"	"	219	"	"	tuberculous ureter

In the fourth decade,	116	out	of	315	due	to	causes not given
	7	"	"	315	"	"	post-op. catheterization
	4	"	"	315	"	"	trauma
	25	"	"	315	"	"	B. Coli pyelonephritis
	6	"	"	315	"	"	pyelonephritis
	12	"	"	315	"	"	tuberculous kidney
	9	"	"	315	"	"	cystocele
	7	"	"	315	"	"	calculus in kidney
	13	"	"	315	"	"	stricture of ureter
In the fifth decade,	54	out	of	222	"	"	causes not given
	4	"	"	222	"	"	trauma
	4	"	"	222	"	"	post-op. catheterization
	27	"	"	222	"	"	pyelonephritis
	24	"	"	222	"	"	stricture of the urethra
	27	"	"	222	"	"	cystocele
	2	"	"	222	"	"	kidney calcium and pyelonephritis
	2	"	"	222	"	"	stricture of ureter
	5	"	"	222	"	"	tuberculous kidney
In the sixth decade,	34	"	"	101	"	"	cystocele
	6	"	"	101	gave no history of vaginitis		
	12	"	"	101	due to pyelonephritis		
	6	"	"	101	associated with urethral stricture		
	3	"	"	101	due to post-op. catheterization		
In the seventh decade,	20	"	"	53	"	"	cystocele
	4	"	"	53	"	"	" and diabetes
	5	"	"	53	"	"	pyelonephritis
	2	"	"	53	"	"	" and kidney calculus
In the eighth decade,	6	"	"	18	"	"	cystocele
	1	"	"	18	"	"	calculus in kidney and bladder
In the ninth decade,	2	"	"	4	"	"	cystocele

Types. The types of female urethritis occurring are: Simple or non-specific urethritis, acute and chronic; gonorrheal urethritis; acute, sub-acute and chronic; tuberculosis which is rare; syphilis, including chancre, secondary and tertiary lesions; chancroid, and lupus vulvæ. A description of each of these types follows.

Acute non specific or simple urethritis. This is perhaps the most frequently noted condition in the female urethra and the most common infective organism is B. Coli. McBee[41] found B. Coli in 50% of his cases of urethritis.

The etiological factors as mentioned in the literature and observed by the author may be grouped under 1. trauma, 2. ascending infection secondary to that occurring in neighboring structures, 3. descending infection secondary to pyelonephritis or cystitis, 4. focal infection, 5. pregnancy.

1. Trauma. Infection due to trauma may occur:

(1) In mucosa irritated by retention catheters left in for a long time.
(2) In the presence of a foreign body, either stones, or foreign bodies inserted in intra-urethral masturbation.
(3) Due to frequent injury from rough or unclean catheterization, or too frequent exploration and treatment.
(4) Due to trauma of delivery.

2. Urethritis due to Ascending infection may extend from any diseased condition around the external orifice, as inflammation of the labia minora, vaginitis, cervicitis, measles, scarlatina, etc.

3. Urethritis secondary to pyelonephritis and cystitis; is the most frequent according to Bugbee's[10] table, being due to pyelonephritis in most cases in the first five decades and to cystocele after fifty years of age. Winckel[102] writes that cystourethritis in which bladder and urethra are both inflamed may be due to cold, erroneous diet, alcoholic excess, or highly acid urine, such lesions being well known to the laiety as cold in the bladder.

4. Focal infection is stressed by Hunner as a frequent cause of urethritis. He calls attention to the frequent association of urethritis with pharyngeal infection, and its association with tonsillitis and grippe are well known.

5. Pregnancy is mentioned by Winckel[102] as a cause, producing a passive or active hyperemia.

The symptoms of acute non-specific urethritis are the cardinal signs of inflammation plus a discharge from the urethra. If the infection is of sufficiently low grade the patient may present no symptoms and be conscious of no pathology at all. On the other hand she may present acute and marked symptoms. They may consist of itching or slight burning or the burning may become severe accompanied by frequency and dysuria. This may cause the patient to hold her urine as long as possible to avoid the pain of passing it. The burning and itching may be intermittent as may the pyuria.

The treatment usually consists of removing the cause of irritation; decreasing the instrumentation wherever possible, if this is the cause of irritation; removing stones or abnormalities; removing foci and correcting matters of hygiene. If this is impossible or does not suffice the inflammation may become chronic and should be treated as indicated below.

Chronic simple urethritis. Inflammations of the urethra which do not clear up in a few days become subacute and then chronic. As in the male the chronic infection is almost always harbored in the urethral glands lining the mucosa and especially in one or both of Skene's glands or the other glands near the external orifice. Non-specific urethritis may be difficult to distinguish from a chronic inflammation due to the gonococcus and may be gonorrheal even when no organisms can be found in the smear or culture other than that of secondary infection, and when no history of gonorrheal infection can be elicited.

The inflammatory lesions are usually limited to small circumscribed areas showing redness, swelling and induration which can often be seen only with the urethroscope. Discharge may be fairly copious or may be so slight as to barely be detected and may contain only a few pus cells. It may be intermittent. Palpation of the urethra through the vagina will often reveal points of tenderness and may reveal areas of induration. Examination of the orifice may show reddening and slight exudate on gentle pressure. The orifices of the glands on exposure will usually be surrounded by red areolæ. Symptoms are the same as in chronic gonorrheal urethritis described below and the treatment is essentially the same.

Gonorrheal urethritis. Gonorrheal urethritis is a common accompaniment of gonorrhea. It is probably always present at some time during the course of gonorrhea in the female and most writers advise routine treatment of the urethra in treating gonorrhea. The urethra alone is claimed by some authors to be the seat of gonorrheal inflammation in the female, but this appears doubtful.

The frequency of gonorrheal urethritis in cases of gonorrheal vaginitis or endocervicitis found by a number of workers is shown in the following table. (W. S. Pugh[69] 1926).

Author	*90% cases showing urethritis*
Brunschke	90
Bumm and Brose	95
Finger	75-90
Fabry	42
Laser	33
Luczney	85
Stein-Schneider	91
Welander	89
Pryor	90

Acute gonorrheal urethritis is an acute exudative inflammation of all of the mucous membrane lining the urethra caused by the gonococcus of Neisser. It is acquired by adults chiefly through coitus, though contamination with freshly used towels or toilet seats may rarely be the source. Infection of young girls and female infants with their much more easily infected mucous membrane not infrequently occurs through use of towels, toilet seats, diapers, careless handling by nurses and freshly contaminated bedclothing.

The acute symptoms may be very slight or severe. It is not unusual for a woman to have and recover from an acute gonorrheal urethritis without knowing that she has had any pathology at all. Or there may be symptoms of itching, burning, scalding during urination and frequency. There may be a heavy urethral discharge of pus containing gonococci, occasionally blood, or a terminal hematuria. There may be severe dysuria, even strangury and the patient may have to sit in a hot Sitz bath to be able to void at all.

The duration of acute gonorrheal urethritis is from one to ten days, but usually lasts three or four days. The urethritis may clear up and then the urethra be repeatedly infected from a coëxisting vaginitis or endocervicitis. Examination shows the external meatus dark red and swollen, with discharge flowing or easily expressed by light pressure. The secretion shows an abundance of coffee bean shaped diplococci, intracellular, and staining negative to Gram. The orifices of Skene's ducts may be exposed with a Kelly hairpin retractor and are seen as pouting red points just within the meatus from which pus may be expressed by a little pressure. Pressure through the vaginal wall shows the urethra extremely tender and the usual cordlike feeling of the urethra is lost due to the swelling present.

Treatment during the acute stage should consist of rest in bed if possible and more or less continuous applications of hot compresses and hot Sitz baths. Hot vaginal douches should be taken four or five times during the 24 hours and a vaginal tampon dipped in some antiseptic solution such as argyrol, weak solution of phenol and glycerine or acriflavine inserted daily and if possible renewed two or three times daily. If the acute stage is not too severe irrigations of the urethra with acriflavine or some other antiseptic may be given as described below under treatment of chronic urethritis.

After from five to ten days the acute stage becomes improved and is called subacute. During this stage the symptoms are much lessened or cease altogether. The orifices of Skene's ducts are usually still red and somewhat pouting and there is some discharge, especially on pressure. The treatment should be continued as in the acute stage except that the patient does not need to be confined to her bed as a rule. The diet may be increased a little and the strictness of the patient's regime somewhat modified. The subacute stage usually continues for about five weeks (Osgood) and then becomes chronic.

Complications of the acute stages are Skenitis and suburethral abscess.

Skenitis is almost a constant accompaniment of acute gonorrhea. The glands may be exposed as above and if they are inflamed may be treated after the acute stage has somewhat subsided. The best way to make a diagnosis of Skenitis is to express the contents of the ducts by gentle massage from below, when a drop of pus will usually appear at the mouth of the duct. Probably the best method of treatment is to express the contents of the ducts and then cauterize with the electric cautery, after anæsthetizing the urethra. Silver nitrate has been used, as have injections into the mouth of the duct of a drop of pure alcohol or carbolic acid; or some weaker antiseptic may be injected.

Suburethral abscess is rare. When it occurs it is found beneath the urethra in the urethro-vaginal septum and is formed from the infection in several suburethral glands whose ducts become closed so that they cannot drain into the urethra but fuse and form an abscess which is exquisitely tender and causes painful and often difficult urination. The abscess may occur beneath the anterior one-third, as is usual, arising from the periurethral ducts there, or it may arise from the mucosal glands near the bladder in the posterior one-third where the symptoms are much more severe than in those abscesses near the urethral orifices. If these abscesses do not rupture spontaneously into the urethra they may be incised through the vaginal wall, especially in the anterior one-third. Osgood advises that in those in the posterior one-third where such an incision is to apt to cause a fistula, he has had good results by either dilating the urethra to 30 or 31 F. under general anæsthetic when the abscess usually drains, or by incising the floor of the abscess through the urethral wall.

Chronic gonorrheal urethritis. Chronic gonorrheal urethritis is often very difficult to detect or to differentiate from a chronic non-specific urethritis. Of course finding the organisms in vagina or cervix will give one a right to presume that any infection in the urethra probably is of gonorrheal origin as will often a history of old gonorrhea; or even, in many cases a history of definite exposure, if this is obtainable, is enough presumptive evidence. As the diagnosis is often of serious importance every means at the disposal of the practitioner should be used to make a thorough examination. The patient may be trying either to aid or to prevent the making of the diagnosis or she may be entirely ignorant of her condition.

To make a diagnosis the following routine has been found practical by the author and may be carried out for the usual case of chronic urethritis. Instruct the woman to come to the office in the middle of the day without having had a bath or douche that day and without having voided for at least an hour previously. Place the patient on the table in the lithotomy position. Insert a loop into the urethra just beyond the meatus and scrape the urethral wall. Spread thinly on two or more glass slides labelled urethra. If much discharge is present the outer part should be cleansed before taking smear with the loop. In cases where discharge is not evident the finger should be placed in the vagina and the urethra milked toward the meatus after which the smear may be taken with the loop as described above. As a check and also for additional findings a smear should be taken from the cervix after the cervix has been cleansed with sterile dry cotton swabs. Where there is a suspicion of infection higher up in the urinary tract a catheterized centrifuged specimen should be examined. Whenever pus is found, the infection is not due to a gonorrhea alone. It may be non-gonorrheal infection above the urethra or a combination of this with gonorrheal urethritis. Where there is a known old gonorrhea or a history of exposure such an examination should be repeated a number of times and particularly, for the corroborating evidence of the cervical smear, after each menstruation for several months. Cultures may be taken in cases where it seems necessary. Complement fixation tests have not proved to be of much value.

Tuberculous urethritis. Primary tuberculosis of the female urethra is extremely rare but it may be secondary to infections near by or higher in the urinary tract, as in the bladder or kidneys. Lowsley and Kirwin,[47] in 1926, quote Hartmann of Paris as reporting a case in 1926. This was of a woman of 27 years of age who had been troubled with pain and frequency of urination for a period of six years, especially at night. Her chest examination was negative but she had a family history of tuberculosis and had suffered from loss of weight, bronchitis and frequent coughs. The urethra was found at operation to be hypertrophied and stenosed. The narrowed portion of the urethra was excised and a new meatus constructed after which the patient recovered rapidly and was in good health. Examination of the excised tissue showed tubercular follicles containing mostly lymphocytes and large granular cells resembling epithelioids were found in the swollen connective tissue.

Syphilis of the urethra. Chancre of the urethra is much more rare in the female than in the male, as might be expected. Lowsley and Kirwin[47] quote Fournier as reporting 7 chancres of the meatus and urethra out of a total of 249 female chancres, and Tanton as collecting from several French authors, concluding that there was a proportion of one female urethral chancre to every 39 elsewhere.

They describe chancre occurring in the female urethra as crescent shape with the center occupying the lower wall of the meatus and the horns extending up on the lateral walls. It is a red, angry looking erosion, with scanty sero purulent exudate surrounded by a wide zone of induration, whose swelling may partially occlude the meatus. It heals slowly due to the constant irritation by the urine flowing over it. It may be hard to distinguish from malignancy. In the canal the symptoms, as described by Lowsley and Kirwin[47], are discharge and induration. The induration may be on the lower wall or may extend completely around the urethra like a cuff. There may be pain on urination. The inguinal glands are usually swollen. Secondary and tertiary lesions of the urethra are both rare and usually when they occur are extensions from the surrounding tissue. Lowsley and Kirwin quote Fournier as stressing the extreme degree of the infiltration of both the chancre and the tertiary lesions, sometimes to the extent that the urethra seems almost to be formed of cartilage. The picture greatly resembles malignancy, being dark red or grayish yellow and bleeding easily on pressure. It is sometimes very difficult to distinguish from a malignant growth although the age of the patient gives some clew, malignancy being more common in later life. However Watson reports a case of cancer of the urethra occurring at 27 years. Quoting from Lowsley and Kirwin, " The development of a gumma is more rapid than that of cancer; and the tendency of all tertiary syphilitic lesions is to form scar tissue and not to become adherent of the underlying structures; usually, also, there is but little discharge. Epithelioma, on the other hand, displays a thick projecting base, bleeds very easily and gives off a quantity of sanguinous offensive exudate. The differential diagnosis can be established by Wasserman test upon the blood and spinal fluid, and by awaiting the effects of antiluetic treatment. But it must nevertheless be kept in mind that a positive Wasserman reaction means nothing more than that the patient has had syphilis and that it is perfectly possible for a syphilitic to develop a malignant neoplasm and in the existence of malignancy, so much time may be lost in awaiting the results of specific treatment that the neoplasm may advance beyond all hope of relief before it is finally recognized." *

Treatment of urethritis. The treatment of a very acute and virulent urethritis has been described under gonorrheal urethritis above. A very acute non-gonorrheal urethritis is rare but when it does occur the urethral and general treatment are the same as for the acute gonorrheal urethritis.

Subacute and chronic urethritis whether gonorrheal or non specific may be treated as follows; The patient should void immediately after coming into the office. The urethra should then be injected with some antiseptic fluid such as freshly made acriflavine, 1–5000, using a blunt urethral syringe as in the technique outlined below on treatment of stricture. This should be done daily until all gross evidence of discharge has subsided. Occasionally, perhaps once a week, it is good technique to dilate the urethra with a Kollman dilator just after the injection has been made.

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* Lowsley and Kirwin: Textbook of Urology. Phila. and New York, 1926, p. 387.

In urethritis of gonorrheal origin while the discharge is active there should be three or four hot vaginal douches daily by the patient. On each visit to the office a tampon saturated with some antiseptic solution should be inserted into the vagina and allowed to remain two hours or more.

Drugs in common use for this purpose are acriflavine, weak solution of phenol and glycerine, argyrol, metaphen, etc. Such treatment should be continued until all symptoms disappear and should be resumed after any positive smears taken at any of several times later.

It is useless to treat the urethra without treating the cervix and vice versa. Gonorrheal endocervicitis has long been considered as a practically hopeless situation in so far as non infectiousness to others in concerned. It is known that many patients can be brought to the point where gonococci are found only immediately after menstruation. Many methods of cure for gonorrheal endocervicitis have been advocated. The most common method is some form of actual cautery. The author has followed the method of Paul G. Morrissey of Nashville, Tennessee, and believes that this is the best hope yet offered for cure of gonorrheal endocervicitis. The data on cases treated by me with this method is as follows:

1. Miss. E. H. Nullipara, age 26. Treated March 8, 1930. Slides made every two weeks to June 5th, 1930, all positive. Patient should have treatment repeated.
2. Mrs. J. W. C. Multipara 5, age 47, badly lacerated cervix. Treated Sept. 27th, 1929 and March 8th, 1930, all slides positive.
3. Mrs. W. C. Nullipara, age 27. Treated Nov. 8th, 1929, slides every two weeks negative to June 5th, 1930.
4. Miss C. M. Nullipara, age 27. Treated Sept. 27th, 1929, slides positive. Treatment repeated March 8th, 1930, slides made every two weeks to June 5th, 1930, all negative.
5. Miss G. F. Nullipara, age 22. Very nervous, fainted when treatment was begun March 27th, 1930. Another attempt made May 10th, 1930, with what was thought to be with little success. Slides every two weeks, all negative to June 5th, 1930.
6. Mrs. E. J. Nullipara, age 20. Treated Feb. 26th, 1930, slides every two weeks. All negative to June 5th, 1930.

7. Mrs. E. M. Nullipara, age 24. Treated Nov. 6th, 1929, slides positive. Treatment repeated Dec. 5th, 1929, all slides negative to June 5th, 1930.
8. Mrs. F. P. Nullipara, age 33. Treated Sept. 27th, 1929, slides positive. Treatment repeated Nov. 6th, 1929, all slides negative to June 5th, 1930.
9. Mrs. F. G. B. Multipara 4, age 34. Treated April 19th, 1930, all slides negative to June 5th, 1930.
10. Mrs. I. G. A. Nullipara, age 30. Treated April 19th, 1930, all slides negative to June 7th, 1930.

This procedure seems to fail in cases where cervix is badly lacerated. It is important in every case to keep the cervix dilated. This is done by the author, each time a smear is made at two weeks intervals.

Morrissey's technique which he kindly wrote out for me is as follows: "In the cervical canal are found folds of mucous membrane which contain many compound racemose glands distributed between external os and internal os. These glands may or may not extend into the musculature. They are practically always involved in gonorrhea with resultant swelling and pus formation. The ducts of these glands become occluded with small abscess formations which are known as Nabothian cysts. In these sealed pockets the organisms may lie inactive for a period of weeks, months or even years. In treating endo-cervicitis by the electro coagulation method, one must use due precaution or else its application may fail to effect a cure.

The technique is as follows: The patient is placed on table in lithotomy position with a negative electrode sufficiently large placed under the buttocks so that the current may pass evenly and smoothly through the parts treated. This electrode should consist of some such material as blocked tin. It is placed in close contract with the patient to prevent jumping of spark which may occasion pain and burning of the patient's buttocks. At this point a large bivalve speculum is introduced into the vagina, bringing into view the cervix which is cleansed with an alkaline solution which removes all pus and debris. After the cleansing process the positive pole in the form of a long straight needle $2\frac{1}{2}$ inches in length is introduced into the cervical canal, through the mucosa. The current is then applied, and results in literally cooking and destroying of all tissue near the needle. A half curve needle is best suited for destroying glands located just inside the external os. It is at this point that most glands are found. Many times a $\frac{1}{2}$ curve needle will penetrate the desired areas which the above mentioned needles will not reach. See drawings of glands and needle application below.

The best guide to tolerance of current is complaint of the patient that she feels severe cramps in the abdomen simulating menstrual cramps. If too severe the current is diminished. This method is carried on until the operator feels that all glands between the external os and the internal os have been completely destroyed. The question that naturally confronts us with this method is: what are the end results — so far as childbirth occlusion and stricture of the canal are concerned?

After an experience of four years I am of the opinion that no greater harm can result from this treatment in the formation of cicatricial tissue than results from gonorrheal inflammation. Certainly nothing can happen any worse than the results of many plans already advocated for treatment of gonorrheal endocervicitis.

With complete destruction of the cervical glands one may be assured of the fact the infected women are effectively and permanently cured of this most loathsome disease. Repeated smears of cases so treated have demonstrated a cure in most cases. These smears were taken every two weeks, one series being taken after each menstruation. After coagulation slight dilation of the cervical canal is necessary to prevent adhesions of new tissue. This dilatation prevents occlusion of the canal. Dilatation is to be stressed because occlusion of the canal will result in cessation of menstrual periods followed by atrophy of the ovaries. In passing it may be stated that several cases of cervical occlusion have been found as result of the commonly advocated cauterization of the cervix." Morrissey, Paul, G.: Treatment of Gonorrheal Endocervicitis.

Morrissey did not mention anesthesia in his description. In working with him for several months and in doing cases of my own since that time I have found that many women need no anesthesia. Some women can be satisfactorily done after the administration of a sedative, but the most nervous types require an opiate before and after treatment. One case which I had, could not be done without general anesthesia.

STRICTURE OF THE FEMALE URETHRA

Stricture of the urethra is a narrowing of the lumen of the urethra, in its entirety, or any part thereof. It does occur in the female, and may either be congenital or acquired.

History. The first mention of this condition found in literature is by Morgagni,[50] who lived from 1682–1772. In his letters he spoke of it as if it had been a subject for discussion in the school at Padua, for he says, "I have frequently dissected female urethræ and attentively examined

* Morrissey, Paul, G.: Treatment of Gonorrheal Endocervicitis.

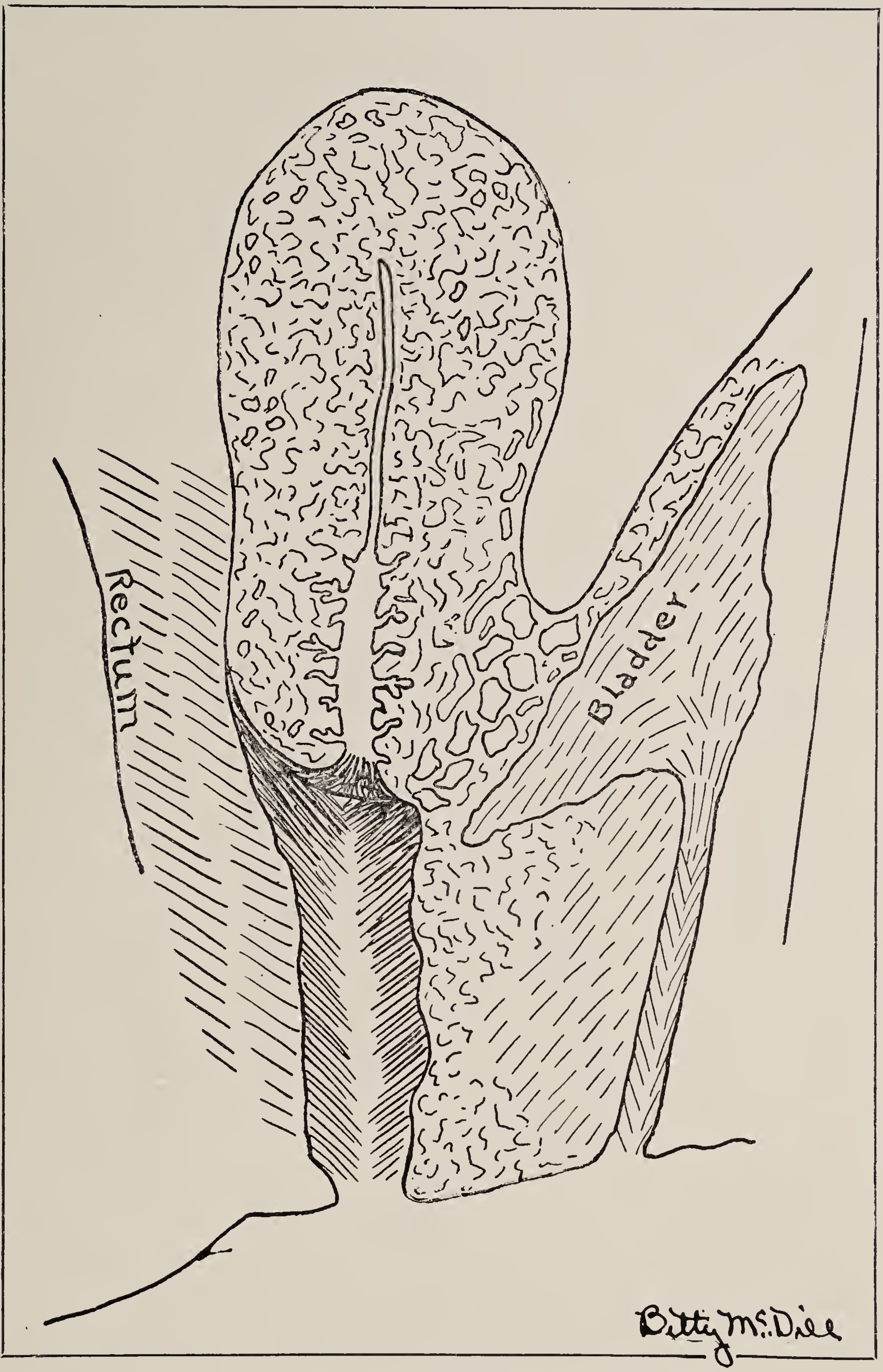

FIG. 15–*a*. Diagram showing location of cervical glands.

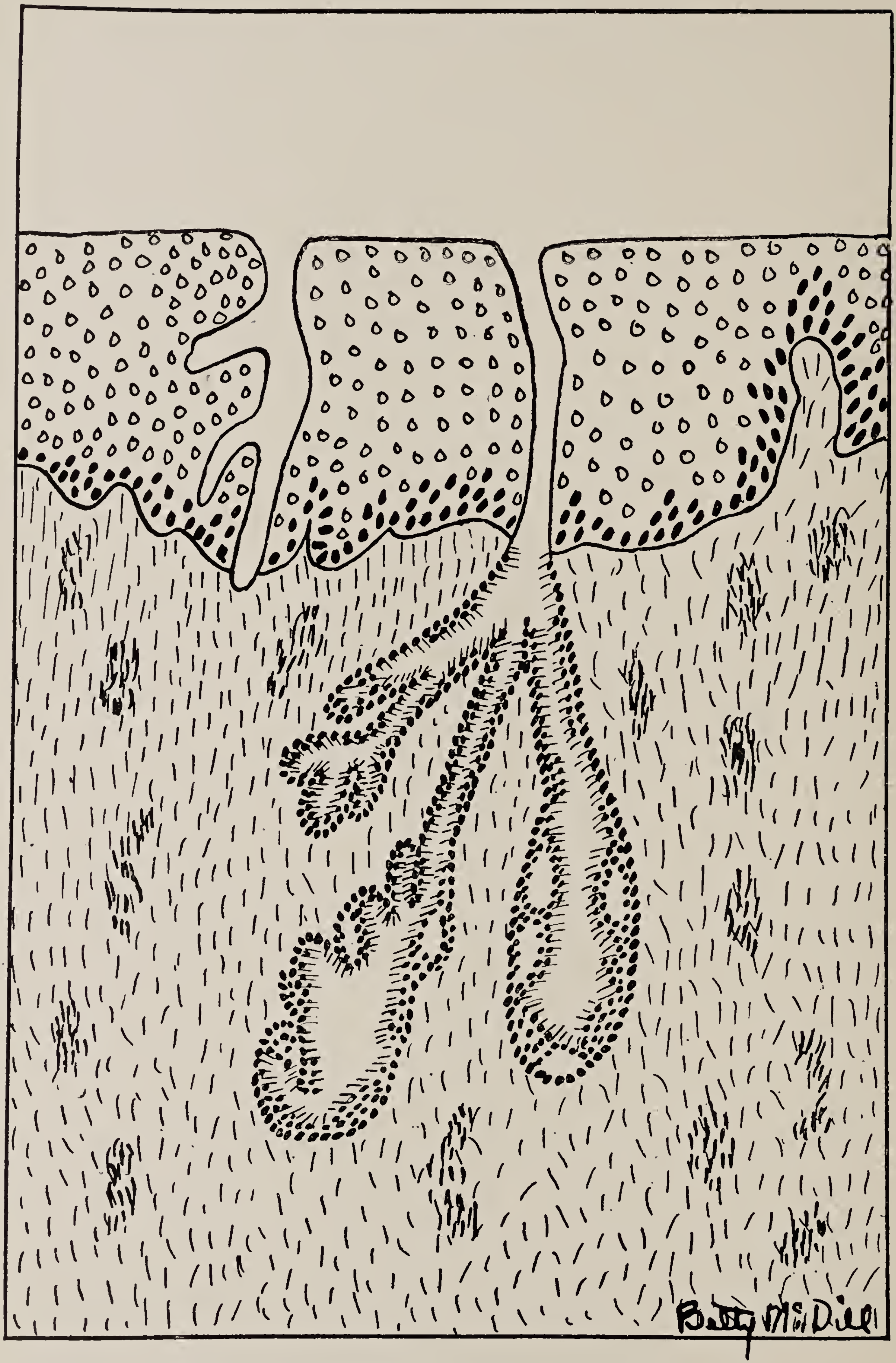

FIG. 15-*b*. Enlarged view of a cervical gland.

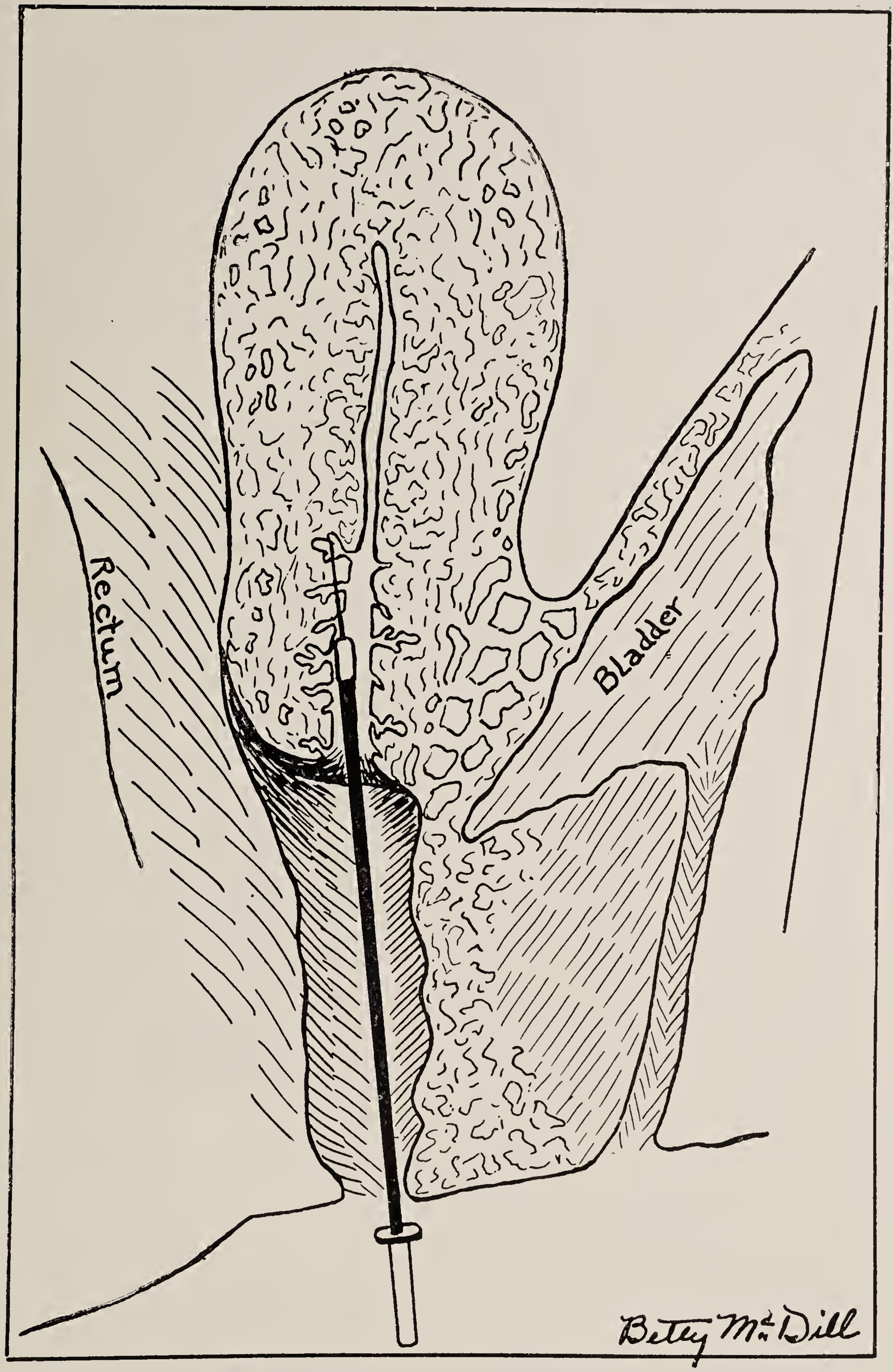

FIG. 15–*c*. Showing long straight needle inserted into cervical gland.

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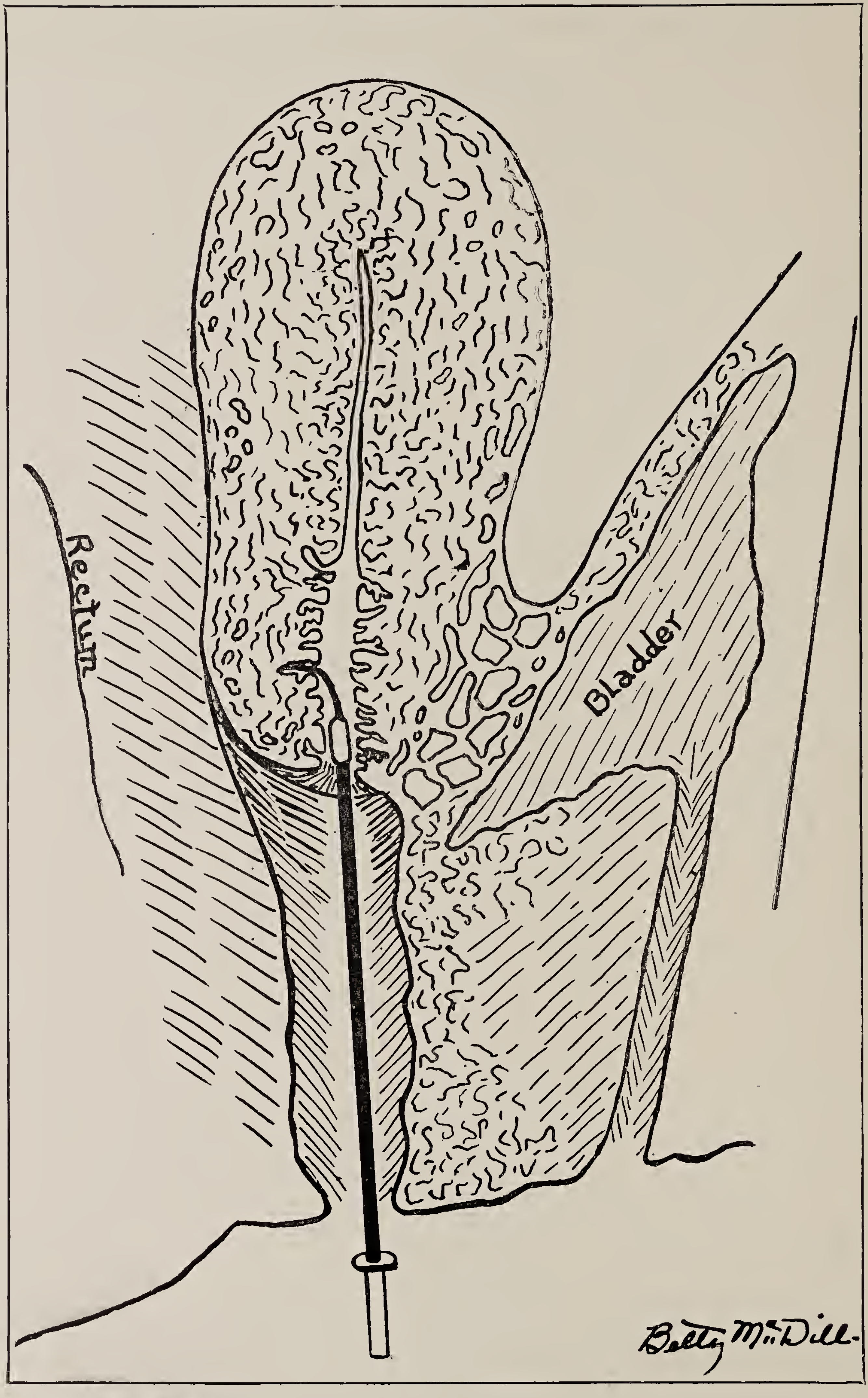

FIG. 15-*d*. Showing curved needle inserted so as to reach depth of gland.

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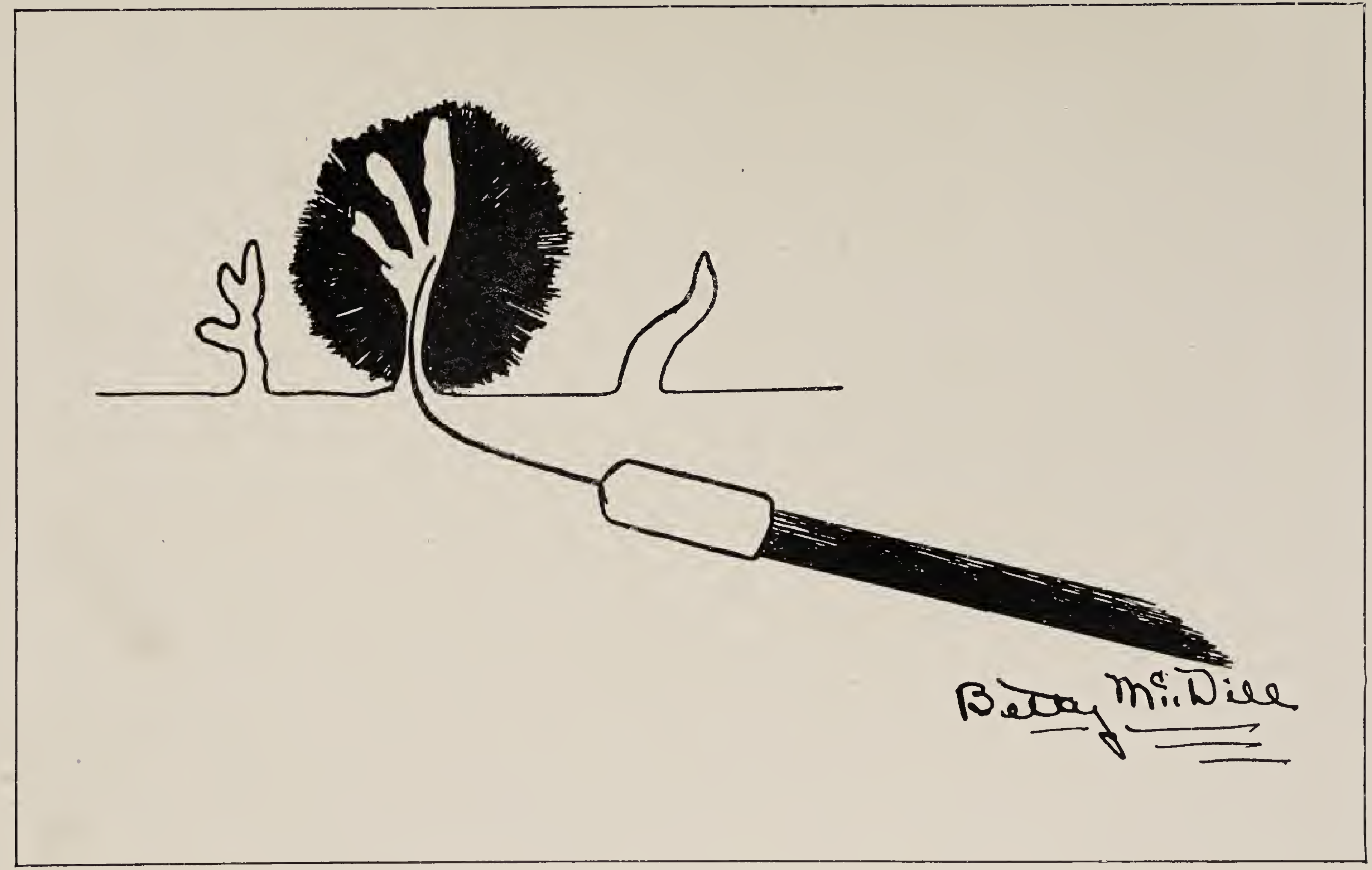

FIG. 15-*e*. Diagram representing in black the area destroyed about the needle.

them, but hitherto, with a solitary exception, I have neither met with the cicatrices nor excrescences, and this circumstance should not occasion surprise, because the canal is short and not very narrow." * (He does not describe the exception).

In 1811 Sir Charles Bell[5] wrote that he had now completely to his own satisfaction, established that the urethra was not muscular, and that inflammation was the cause of stricture. In 1869, Sir Henry Thompson[88] wrote a paper upon the subject. "Pathology and Treatment of Stricture of the Urethra and Urinary Fistulæ", in which he stated that the extreme rarity of its occurence was not difficult to account for, because the passage itself was so short. Up to 1869 we have authentic reports of five cases and brief mention of others.

Credit has often been given Lisfrance for first drawing attention to stricture of the female urethra, in 1824. In 1874 Otis[56] read a paper, "Reflex irritations throughout the Genito-urinary tract, resulting from contraction of the urethra, congenital or acquired." Emmet, in 1882, expressed his opinion that stricture of the female urethra was rare, except from violence.

In 1890 Ely Van der Warker[92] came out with the bold statement that urethral stricture or contractions sufficient to cause symptoms were as frequently found in women as in men. In fact the title of his paper was "Stricture of the Urethra in Women." He contended that strictures were not found because they were not looked for. In 1892 Otis,[56] of New York, came out with his second paper on the subject, entitled, "On Reflex Irritations and Neuroses Caused by Stricture of the Urethra in the Female." In part he says "symptoms in the female, which in the male would be at once accepted as indicating the probable presence of a urethral stricture, have often been recognized and referred to under the title — Irritable Bladder — and attributed to causes quite independent of their possible relation to the urethra. It has been emphasized that over-distention of the urethra gave relief, but necessity of examination was lost sight of." †

In 1895, Wm. S. Bagot,† of Denver, Colorado, wrote a paper on the subject. Kelly and Burnam, in 1897, mention it briefly in their textbook, and also state there that Pastan had collected 112 authentic cases.

Incidence. Otis[56] in 1892 reports four cases and remarks that stricture of the female urethra is more frequent than was supposed. Urethral stricture was formerly thought to be much more rare than it actually is. In 1922, Wm. Stevens,[81] of California, contended that stricture of the urethra in women was very often overlooked though it was responsible for marked functional and organic disturbances in the genito-urinary tract. Pugh[66] in 1924 reports in detail 35 cases of urethral stricture found in 180 female urological patients examined by himself. In 1927 he reported additional cases of stricture. Bugbee[10] in 1917, reviewed 910 cases in women and girls, giving a complaint of frequency. His results follow with the age incidence:

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* Morgagni, John Baptist: Seats and Causes of Disease Investigated by Anotomy; Ped. by Wm. Cook, 1824.

† Otis, Fessenden N.: On Reflex Irritation and Neuroses Caused by Stricture of the Urethra in the Female. Med. Record 41: 34, 1892.

3rd. decade	219	cases	with	6	strictures
4th. “	315	“	“	13	“
5th. “	222	“	“	24	“
6th. “	101	“	“	6	“
7th. “	53	“	“	2	“

Thus in this total of 910 cases complaining of frequency, there were found 51 strictures.

Wynne,[104] in 1922, reported a series of 47 cases of urethral stricture in the female. The age incidence is shown in the following table.

19 years	1 case
20 to 30 years	12 cases
30 to 40 “	9 “
40 to 50 “	8 “
50 to 60 “	10 “
60 to 70 “	6 “
70 “	1 “

Location. As to the location of stricture in the female urethra there has been some difference of opinion. Wm. E. Stevens[81] expressed his opinion that it is uncommon in the middle portion of the lumen but frequent in the meatus, congenital or acquired. Thomas Addis Emmet[19] says that the narrowing usually takes place at the outlet. Bagot thinks that it occurs most frequently in the anterior one-third or near the external meatus. Lowsley and Kirwin state that while strictures have been observed in all parts of the urethra the most common locations are at the external orifice and the anterior section. Kelly and Burnam state that urethral stricture may occur in any part of the urethra and may be linear or annular.

Wynne[109] reports a series of 38 cases as follows:

Entire urethra involved	4
External meatus “	9
Anterior “	14
Middle third “	7
Posterior third “	4

Pugh[67] reports 35 cases in the following locations:

Entire urethra	involved	0
Meatus	"	18
Anterior	"	12
third	"	1
Posterior third	"	4

Skene[76] first called attention to the internal orifice. Gaulk,[11] in 1921, emphasizes the frequency and importance of stricture around the internal sphincter, and reports one case. McBee[49] in 1926 reports a similar case. Sir Henry Thompson, in 1869 gave the most common location as the external orifice. He further stated that it rarely pervaded the whole urethra, or the posterior part of it. In the same year Blundel reported two cases involving the whole urethra from end to end. Such cases however are rare. The author has seen most cases at or near the meatus. The exceptions to this were seen in cases of malignancy. The consensus of opinion seems to be that urethral stricture in the female can occur in any part of the urethra, but is more common about the meatus and anterior third of the structure.

Stricture may be single or multiple, although only a few multiple strictures have been reported and are rare. The location of a stricture is easily determined. If a bougie is passed into the urethra while a palpating finger is in the vagina, the point of stricture can be determined by the difference in the resistance offered as the bougie is inserted, or more accurately, as described elsewhere, by the hang of the bougie on withdrawal.

Pathology. In stricture of the female urethra, the degree of narrowing of the lumen varies within quite wide limits. It may have progressed to that degree where the flow of urine is only slightly retarded, or on the other hand it may have so narrowed the lumen that the urine flows only in drops, or that there is even complete obstruction. The latter extreme condition is however a rarity. A urethra with a diameter less than 26 F. is probably abnormal and the diameter should be the same throughout. Stevens reports measuring urethral strictures ranging in size from 22 F. to such as would not admit a filiform.

Pugh[66] gives measurements as follows on 85 consecutive cases of stricture:

Admitting	filiform	1
"	No. 8 F	3
"	" 12 F	10
"	" 14 F	21
"	" 16 F	17
"	" 18 F	13
"	" 20 F	11
"	" 22 F	10

Wynne[104] reports a series of 33 cases of urethral stricture with the following measurements:

8 cases	2 mm.
7 "	3 mm.
4 "	4 mm.
1 "	5 mm.
2 "	6 mm.
4 "	very small
3 "	just admitting probes
1 "	admitted finest bougie obtainable
3 "	Unable to enter, had to puncture with trocar.

Causes. Many are the causes of urethral stricture mentioned in literature. Sir. Chas. Bell[5] (1811) concluded that all strictures were due to inflammation, and he was the first one, later on, to link up gonorrhea with stricture formation. In 1840 the Paris Hospital Gazette reported a case in which a chancre acquired ten years previously had been the cause. Sir Henry Thompson attributed stricture to excrescences. Emmet,[18] 1882, said that stricture was rare except as a result of violence, the use of nitric acid or other caustics, the cautery, or after cutting off of prolapsed tissue or growth from meatus. Van der Warker[92] believed that in the sexual act the urethral meatus and prominence were as much exposed to friction and contact as the urethral opening in the male, and that this might be a causative factor.

Bagot,[2] (1895) stated that gonorrhea was the cause of one-third of all reported strictures, and that the average age was 39 years. According to Bagot the stricture usually appeared in the eighth year after the onset of gonorrhea. In some cases it appeared at the end of the first year, and in others in the twentieth year. Other causes listed by Bagot were: 1. injury during labor, 2. puerperal inflammation, 3. urethral chancre, 4. congenital, 5. senile contraction, 6. long existing vesicovaginal fistula and 7. too frequent cauterization.

Kelly and Burnam contended that stricture was usually due to infection. Wynne[104] mentions such causes as childbirth, intra-urethral masturbation, burns and scalds, operative injuries, caustics, tuberculosis, syphilis, chancroid, diphtheria, typhus fever, kraurosis, lupus vulvæ, carcinoma, polyps, vascular and fibrous tumors, extra urethral growth and congenital stenosis.

Pugh reports 35 cases with gonorrhea the cause in 24, chancroid 2, syphilis 1, childbirth trauma 1, possible focal infection 5, and one not given.

Lowsley and Kirwin mention that the inflammatory conditions which may cause stricture are gonorrhea, syphilis, tuberculosis, and any other inflammatory disease which may cause inflammation of the vulva. They further state that syphilis is apt to cause a generalized thickening throughout the whole canal, while gonorrhea is an important factor in strictures near the meatus. They also consider traumatic and congenital strictures not infrequent. Congenital stenosis is mentioned by a number of urologists as being of frequent occurrence. Wynne[104] found that Blum and Fissiaux each reported a case of congenital stricture accompanied by a patent umbilicus and persistent urachus. Stevens,[18] in 1930, although believing gonorrhea and trauma to be the chief causes of stricture, states that congenital stricture is not rare. Boyd, in 1929, wrote a paper stressing the importance of congenital stricture at the meatus. He states that a large portion of the strictures in female infants and little girls are congenital, and that congenital stricture is a frequent cause of pyelitis in little girls. He describes a small fold found on the lower wall of the urethra in many cases which narrows the meatus. The fold, which may be seen on examination, and which is reponsible for the symptom frequently noticed by the patient of the deflection of the stream of urine upward, is considered by him to be diagnostic of congenital stricture. Hunner clings to his idea of focal infection and stresses the frequency of the occurrence of urethral strictures in his cases of ureteral stricture, finding that they are present in 60% of all cases of ureteral stricture.

Herman thought that in women about 50 years of age a senile thickening of the urethrovaginal septum was a frequent cause. Cases have been thought to be due to infectious diseases such as scarlet fever, typhoid, and pneumonia, but definite proof of this has not been established. Astringent vaginal douches have been mentioned as a cause. It has also been mentioned that change in the urine acidity or alkalinity, especially in people who are a little unclean in their habits, may cause inflammation of the urethra with subsequent stricture.

The author has seen no stricture in the female urethra which could be attributed directly to gonorrhea; however, it should be remembered that in women of good character a history is extremely hard to elicit because of their ignorance of such a malady. They attribute all of their disorders merely to the fact that they were married and every ailment of the urinary tract is termed either female trouble or kidney trouble. The most of the strictures seen have appeared to be either congenital, which usually occur at the meatus, or traumatic which are usually the result of childbirth.

In summary, the concensus of opinion among contemporary urologists would place the causes of stricture in the order of their importance somewhat as follows;

1. Inflammation, with gonorrhea in the lead, including syphilis, chancroid, tuberculosis and lupus vulvæ.
2. Trauma, due to childbirth, cauterization, operative procedures, intra-urethral masturbation, coitus and burns.
3. Congenital stricture.
4. Tumors, including carcinoma, polypi, vascular tumors, fibrosis, and extra-urethral tumors.
5. Focal infections.
6. Vesicovaginal fistulæ.
7. Infectious diseases.
8. Senile contraction.
9. Kraurosis.

Symptoms. The symptoms of stricture are numerous and varied, depending upon the calibre of the stricture, the amount of inflammation present, and the reflex sensibilities of the patient. Many attempts have been made to establish a normal calibre for the urethra but as yet there is no accepted normal standard.

Sir Henry Thompson, in reporting a case, summed up the symptoms as " Continued and urgent desire to pass urine, which at times passed involuntarily, and had for some months been loaded with a thick mucopurulent secretion; a constant sense of bearing down, burning heat of the urethra, and great pain after making water, and a constant urgency to make more after she had emptied the bladder. The sufferings gradually increased until a stillicidum took place." *

Bagot[2] (1895) mentioned such symptoms as difficulty with or without pain, gradually decreasing volume of stream, eventually complete retention, and maybe pyuria, hematuria and tenesmus. Van der Warker (1890) claims that the symptoms appear earlier in women than in men and mentions that they frequently have exacerbations after periods of days or weeks.

Kelly and Burnam stated that urethral stricture in the female might give all the symptoms of cystitis. Wynne observes that the onset is gradual and mentions the symptoms of a small stream, occasional dysuria, acute retention, symptoms of cystitis, strangury, pollakiuria, ischuria, nocturia, tenesmus and dribbling.

Skene says that stricture near the vesical neck causes symptoms out of all proportion and may be due to interference with the sphincter.

Caulk states that symptoms of irritable bladder in those cases near the internal sphincter may be very annoying.

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* Thompson, Sir Henry; Pathology and treatment of the Urethra and Urinary Fistulæ, 3rd. ed., 1869.

Symptoms may be referred to parts of the urological tract higher up, for example the kidney. E. Mac D. Stanton[80] suggests that in those cases of urethral stricture presenting symptoms of renal colic, the symptoms may be due to painful contractions in the urethra after urination which are transmitted through the trigone to the ureter.

In summary, the most common symptom of stricture of the urethra seems to be frequency, and then difficulty of urination. A large percentage of cases coming to the urologist complaining of frequency show urethral stricture. Many women have complained that it takes them longer to urinate than it formerly did. Some have noticed that the stream is not as full as it once was because it makes less noise when voiding in the toilet.

A great many strictures of the female urethra attract no attention until the patients have the usual symptoms of pyelitis, such as general malaise, backache, frequency, dysuria, etc. Just recently the author saw an old lady 76 years of age, sent in by a general practitioner with the diagnosis of pyelitis. Her urethra was found to be calibre 16 F. at its narrowest point. Supposedly cystitis and pyelitis resulted from urethral obstruction. The urethra had to be dilated by degrees to make cystoscopy possible. Immediately after the first dilatation the patient showed marked improvement.

Three weeks elapsed before the urethra was dilated to 28 F. By this time the patient was free of symptoms, had gained 10 pounds in weight, and was able to stay out of bed all day. She reluctantly came to the office for treatment. Since that time she has been questioned once every week and always says that she feels better than she has felt for several years, and on most occasions urinalysis has been negative. There is perhaps no doubt that she still has a low grade pyelitis, but as long as it causes no discomfort there is no point in subjecting a woman of her age to the ordeal of a pyelogram and other procedures included in a complete cystoscopy. She now has been in what might be termed perfect health for more than six months. (June 16, 1930.)

Diagnosis. The calibre of the urethra should be examined as a routine in all urological examinations. A stricture at the meatus can be recognized in a careful inspection. The urethra should be at least 26 F. and uniform in size throughout. To diagnose a stricture use an olive tipped hollow bougie. Any size bougie which will enter the urethra should go to the bladder sphincter and return without hanging. If a 26 F. enters and passes and there is any reason to indicate that the trouble is in the urethra a 28 and 30 F. should be passed. A hang on withdrawal of the bougie will indicate a stricture. The point in using a hollow bougie is that in inexperienced hands the bladder sphincter may be mistaken for a stricture, but when the sphincter is passed urine will flow through the bougie.

Differential diagnosis includes cystitis, trigonitis, urethritis, urethral ulcer, bladder ulcer, tumors and displacements, malformations of the urethra, interference with normal bladder function by pressure of the gravid uterus, pelvic tumors, and retention from other causes.

Treatment. As to the treatment of stricture of the female urethra, in 1811, Bell wrote that he had dilated a stricture by making the patient wear a small tube in the urethra, so that what had been a stricture came to be the widest part of the canal. Sir Henry Thompson recommended a division with a cutting instrument followed by the use of bougies. With such treatments, he reports that his cases obtained complete relief. Kelly and Burnam recommended dilatation, electrolysis and incision. Thomas A. Emmet, in 1882, recommended that in cases with narrowing at the outlet, that the outlet should be divided backward sufficiently to restore it to its natural size. Van der Warker, (1890) wrote that the treatment should be twofold; to dilate gradually and to cause absorption of constricting exudate, and that the latter is not attained by sudden and forcible dilatation. He advised dilatation 2 or 3 times per week over a considerable period of time, saying that relief came early. Otis (1892) also advised overdistension. Wynne[104] (1922) listed the methods used by himself in the treatment of 55 cases.

Good dilatation	20
Rapid dilatation	12
Internal urethrotomy and dilatation	5
Electrolysis	5
Passing of catheters	4
Puncture and dilatation	3
Removal of tumors and dilatation	3
Division of urethrovaginal septum, near meatus	1
Resection of stricture	2

In 1922 Wm. Stevens recommended (1) gradual dilatation, (2) meatotomy. In 1930 he stated that female children yield readily to dilatation while incision is usually required in males. As to dilatation, he uses F. sounds increasing two numbers at each treatment until 30 F. passes easily. Following withdrawal of the sound, a few cc. of 1% silver nitrate is injected into the bladder and urethra. He advises two treatments each week at first, gradually lengthening to one a month. He uses 10% cocaine in nervous women.

Boyd[7] advises meatotomy in strictures around the meatus. In performing a meatotomy he put 4% cocaine in the meatus on cotton, packs the vagina with a little piece of gauze, and using a small round-bellied knife divides the lower lip of the meatus with a hurried stroke. He says there is as great a need for meatotomy in the female as in the male, perhaps greater, and states that a single meatotomy will clear up many cases of pyelitis in little girls.

Caulk[11] reports using the Caulk cautery punch with good results in a case of stricture in the region of the internal sphincter.

Dilatation is the principle solution but time and speed are dependent upon many factors, such as location, type of stricture and coëxistent illness. Usually it is best to dilate gradually at the rate of about 2 cm. per week using one dilatation per week and two or more urethral injections of some non-irritating antiseptic fluid. It may be well to mention here that it is best not to introduce any instrument into the urethra except for dilatation or for inspection beyond the urethra. The most satisfactory and the simplest procedure for medicating the urethra is as follows; with palm upward hold a one-half ounce blunt pointed bulb syringe between the forefinger and the middle finger with the bulb upward, then place the point of the syringe well into the meatus and with the thumb press upon the dome of the bulb, at the same time asking the patient to bear down as if voiding. The bladder should be emptied before this treatment is given. This method has many advantages, among them that the medication of the urethra can be done by the nurse and not require the attention of the urologist. This method is explained because the author learned recently, while lecturing to a class of 36 nurses, that none of the nurses had ever heard of any way to medicate the female urethra except through a catheter. It was emphasized by the fact that since that time private nurses in charge of female cases had to be taught this procedure in every instance.

Too rapid dilatation is to be condemned. Unfortunately, many practitioners and a few urologists have the idea that dilatation can be safely done by the insertion and opening of hemostats, either with or without anesthesia. At present the writer is contending with a case seen in consultation with a general practitioner more than a year ago. She had a large amount of pus in the urine but presented the symptoms of a typical acute appendicitis. The general practitioner insisted on a cystoscopy. When cystoscopy was begun it was found that the patient, a student nurse, age 18, had a congenital stricture at the meatus calibre 14. Cystoscopy was abandoned for the day. That night an emergency appendectomy was done and an appendix lying on the ureter and gangrenous was removed. The surgeon who removed it had been told of the stricture. He decided that while the patient was asleep was a good time to dilate the urethra. He inserted hemostats and opened them. The result was that the urethra was torn wide open. The girl now has a false pocket in the urethra, similar to that often encountered in the male urethra. It is impossible to catherize her with a soft catheter, the only method of catherization is to use a curved Coudé, inserting the finger in the vagina to guide the point of the Coudé out of the false pocket. It stands to reason that she did not have a false pocket in the urethra at the time of the first examination because a number 12 soft catheter passed directly into the bladder without obstruction.

By way of summarizing treatment, gradual dilatation, and in some cases urethrotomy or meatotomy, give the best results. The dilatation must be very gradual, usually once each week, over a sufficiently long period of time, and the size 26 F. to 30 F. must be reached. Of course, tumors or other causes of the stricture should be removed. Finally the patient should return for examination every few months until there is no danger of recurrence.

NEW GROWTHS

There is a wide variety of new growths found growing in or involving the female urethra. Among such tumors are mentioned caruncle, carcinoma, angioma, sarcoma, myxosarcoma, fibroma, fibromyoma, polypi, papillomata, condyllomata, cysts, and varices. These tumors may be classified as those arising from epithelium, connective tissue, glands, blood vessels, or any combination of these.

CARCINOMA

Carcinoma of the Female Urethra may be primary or secondary. Primary carcinoma was first reported in 1833. It is a relatively rare condition as indicated by the following data.

In 1922 O'Neil[55] could find only 67 cases and reported one of his own, bringing the total up to 68 cases.

In 1922 Kelly and Burnam[59] found it to be rare.

In 1923 Culver and Foster[15] believed they had found authentic reports of 120 cases and reported three of their own. In the same year Wm. Fletcher Shaw[74] could find only 100 cases which he considered authentic.

In 1924 O'Connor[54] found 99 cases in the literature.

In 1925 A. C. Palmer[59] in a rather exhaustive search could find only 105 cases he considered authentic.

Scholl and Braasch,[72] writing in 1922, quoted Englisch's citation of

Gerdt's statistics from Vienna clinic. There were 16,637 cases of tumors with none of the urethra. Up to that time there had been only four primary malignant tumors of the female urethra, at Mayo clinic.

The literature is flooded with cases in which carcinoma has invaded the urethra from adjacent tissues, most commonly the bladder and cervix. Extensive cases may involve all neighboring tissues, vestibule, clitoris, etc.

Origin. Most pathological reports indicate that epithelial tumors arise from the mucosa or from Skene's glands. Pomeroy[64] was of the opinion that carcinoma may result from malignant degeneration of a caruncle.

Diagnosis. Depending upon the history many of these cases may be confused with Syphilis or Chancroid. Sometimes what looks like an ordinary caruncle may be carcinoma.

Usually carcinoma is not excruciatingly painful to touch. It may or may not bleed easily, but usually does. Kelly and Burnam describe secondary involvement by saying, " Nodules are first felt under the bladder, then under the urethra, until the entire urethra becomes converted into a rigid tube urethra in cuirass." *

Most cases occur after menopause and are rare in nullipara. The youngest case found was 26 years of age.

Symptoms. Onset of symptoms may be sudden or gradual. There is a wide variation of symptoms ranging from that of a slight and painless bleeding to a partial or total combination of dysuria, difficulty, soreness, hematuria, partial suppression, frequency, incontinence, itching, burning, tenesmus, loss of weight, hemorrhage, constipation, constant pain temporarily relieved by voiding, bearing down pains, urethral discharge with or without odor, pain radiating into thigh, painful coitus, The group of symptoms is governed by location and type. It stands to reason that the ulcerated types cause most pain in voiding. Some of these patients have continual pain except when they are on their back with limbs spread apart.

In many cases the tumor is not readily discovered. It may be in the form of an ulcer or a polyp.

Whitehouse[101] had made a clear division as follows;

1. Vulvo-urethral. (*a*) Irregular dark purple papillomatous growth which bleeds readily on contact, and which may be mistaken for a simple polypus or a caruncular condition of the urethral orifice.

(*b*) An ulcer produced by the breaking down of a nodule on the floor of the vestibule at the urethral orifice. The ulcer presents the usual malignant character having a hard indurated irregular margin and friable sloughing base. It rapidly involves the whole of the vestibule and spreads to labia minora.

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* Kelly and Burnam: Diseases of Kidneys, Ureters and Bladders, 1914.

(*c*) An induration surrounding the urethral orifice leading to depression, puckering, and contraction of the orifice itself, but free from all ulceration and proliferation. This appears to be of slow growth and clinically is a scirrhus.

2. *Urethral Growths:*

(*a*) Irregular elongated ulcer involving mucous membrane of urethral canal and only exposed by urethroscopy. The ulcer is usually situated on the floor of the canal in the distal segment. It has the usual malignant characters and tends to grow towards the urethral orifice. It rarely involves the bladder.

(*b*) Periurethral induration; Free from ulceration until later stages. A definite tumor is formed which tends to occlude the urethral canal and which involves the whole length of the urethra. This type is of slow growth and approximates the scirrhus type. In its later stages ulceration occurs in the vagina, urethra or vestibule.

Whitehouse then calls attention to the fact that all types are similar in the last stages.

Inguinal node involvement is usually early. Kelly and Burnam describe the spread as occurring along the length of the urethra into the bladder or out into neighboring tissue and along the inside of pubic ramus to inguinal nodes and other structures.

Case reports, Culver and Foster[15]:

1. Woman, age 65, for two or three years had suffered from frequency and burning. For three weeks there had been pain in left side and abdomen, getting worse and radiating into thigh. Examination revealed a nodular mass apparently surrounding the urethra, but not involving urethral mucosa, and extending as far as the bladder neck. No external evidence of growth in urethra. Fatal.

2. Woman, age 38. Seven months before coitus had been painful. It became more so until in two months it was impossible. The next two months there was constant pain in bladder neck which was markedly increased on sitting down. From the first month there was gradual increase in frequency, until within four months both nocturnal and diurnal frequency had increased to practical incontinence. There was no hematuria, no loss of weight, but considerable loss of strength.

Mrs. J. E. W. E. Nashville (Author's case). Age 57, came in complaining of frequency of urination and bearing down sensation in pelvis. Previously she had passed huge blood clots from vagina and had become very weak but somehow thought such occurrences were a part "of old age." Examination revealed a small firm urethra which admitted only a filliform. Vesicovaginal floor and cervix were boardlike in consistency. The cervix bled easily. Small piece of tissue removed from cervix was diagnosed as carcinoma by pathologist. Patient died in three months of what was thought to be metastasis to liver. Original site of carcinoma was not determined.

Pomeroy. Patient complained only of bleeding and inability to hold urine, once the need to pass it was recognized. Slight bleeding had been noticed six months previously. Loss of blood had been slight and occasional for four months, this followed by considerable daily loss for thirty days. Since then bleeding had been irregular and variable in amount. The patient was a plump well developed, muscular woman, well except for hemorrhage.

Examination: The anterior vaginal wall along the line of the urethra felt harder than the remaining mucous membrane. There was no inguinal gland involvement. A pea-size lump was squeezed out of the urethra during examination. A growth occupied the floor of the urethra extending back about an inch. Pomeroy had another case which had bleeding from external meatus, swelling and pain in external meatus, burning and frequency. Later there was severe bleeding.

Treatment. Treatment has been advised for this condition which ranges from conservative implantation of small amounts of radium to that of complete resection of the urethra, bladder and all involved glands, administering both X-rays and radium afterwards in maximum doses. Kelly and Burnam advise to treat surgically as radically as demanded and use radium afterward.

Scholl and Braasch's [72] cases (3).

1 treated with Percy cautery and radium, well 6 years later.

1 treated with radium became hopeless in 11 months.

1 treated with radium apparently well, time not given.

Pomeroy and Milwood think that radical procedure such as resection of bladder is rarely necessary. They believe that the vesical sphincter can be saved in most cases, and that there is some value in the electrocautery, and that radium is best in advanced cases, and X-ray best for regional lymphatics.

Richard F. O'Neil [55] quotes Cressau as advising radical excision when confined to the urethra, resecting around the urethra and up to the bladder neck. Use of purse string suture to pucker up muscle tissue at bladder neck was recommended with pre-operative drainage by vesicovaginal fistula, the fistula to be closed later if it does not close itself. The fistula to be permanent when the bladder neck is involved. The results in twenty-five cases quoted from Cressau were:

Cures	3 years	8
Probable cures	2 "	3
Recurrence known		8
Results unknown		6

Diathermy has been tried in many instances and resulted in temporary comfort in some cases.

A. C. Palmer[59] reviewed thirty cases in which a total resection of the urethra had been done. He found very little difference in the two types. A. Vernat and A. Parcelier found recurrence in $33\frac{1}{3}\%$ of 28 cases of partial resection, and recurrence in $16\frac{1}{2}\%$ of 30 cases of total resection. They spoke of the use of radium as being encouraging. Wm. Fletcher Shaw[74] seems more or less doubtful of all procedures, but perhaps favors radium.

Sarcoma. Sarcoma of the female urethra is very rare. The first case found reported in literature was by Beigel in 1875, Fig. 16. Earliest age reported was three months. The etiology is unknown. Diagnosis is certain only when made by microscope. Most common occurrence has been in patients of from 25 to 55 years of age.

Origin is thought to be from connective tissue about the urethra. The tumor may project from urethral meatus or remain entirely inside urethra. It may even be pedunculated. Like sarcoma of the testicle it grows rapidly and metastasizes rapidly. Scholl and Braasch quote Reed's report of a case in which he observed abdominal metastasis seven months after removal of sarcoma from urethra, and Watson's inoperable case which died in four months.

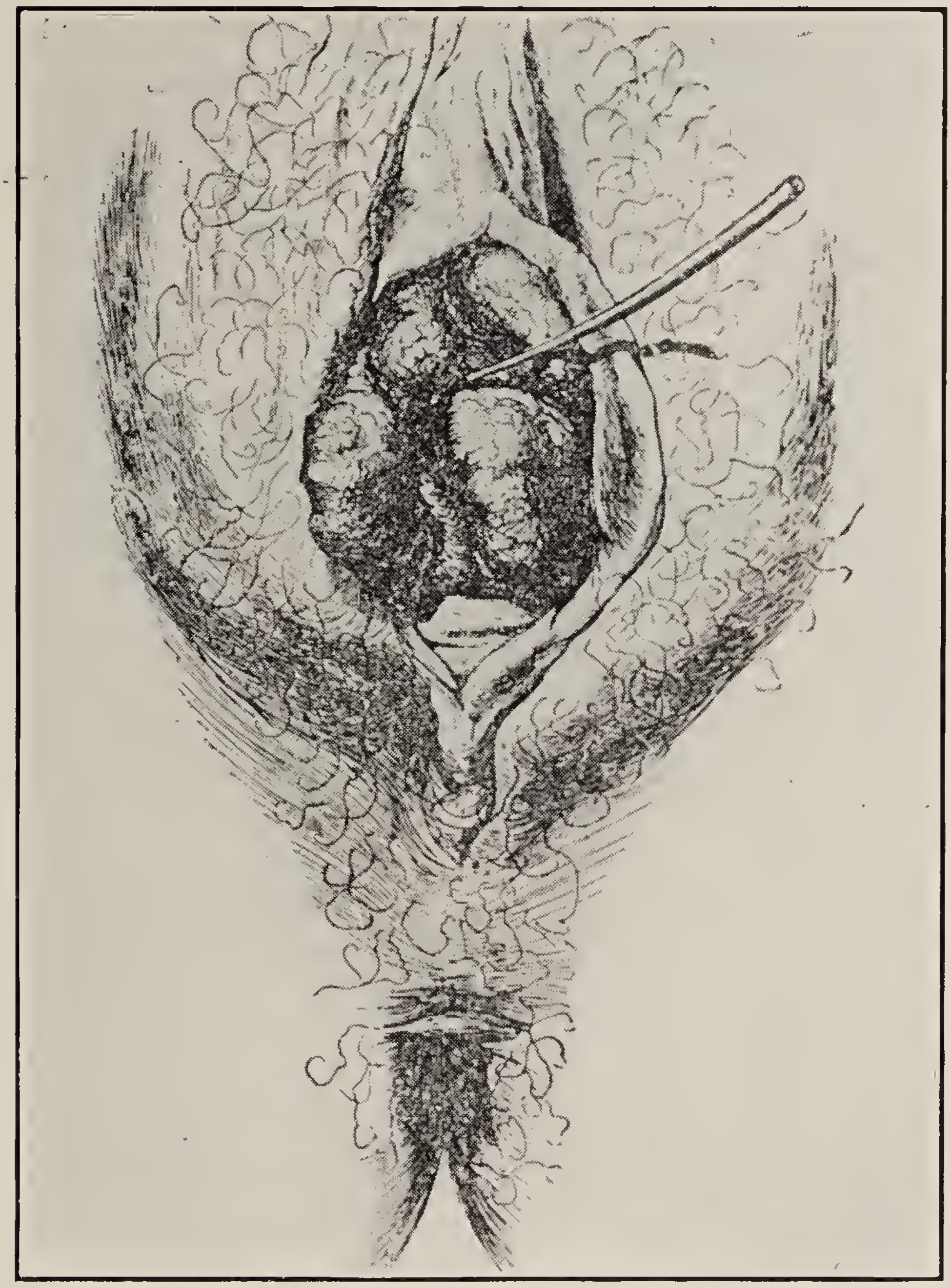

FIG. 16. Sarcoma of the Female Urethra.

Kelly and Burnam's description of a typical case from Ehrendorfer is, "For eighteen months the patient had noticed an enlargement at the urethral orifice, and had a bloody watery discharge without odor. There was no active bleeding except from direct contact. There was a livid tumor protruding at the site of the urethra divided by deep fissures. The mass was attached at the lower and urethral margin. On making an incision the tumor was found to have a brainlike grayish appearance. It was moderately firm and showed small hemorrhagic areas." *

Treatment. Some authorities have found temporary relief from radical surgery. Keyes says that sarcoma of the female urethra is incurable.

Other malignant tumors. Spindle Cell Sarcoma (Scholl and Braasch),[72] myxosarcoma (Scholl and Braasch) (Kelly and Burnam), and myxo-fibrosarcoma (Kelly and Burnam), have been reported, but are very rare. Treatment is of little or no avail.

Fibroma, myoma and fibromyoma. Are benign tumors of rare occurrence and are practically the same in location, production of symptoms and gross appearance. They consist of fibrous or muscular tissue or both and have their origin from tissues under the mucosa. They may be multiple or single, and they grow very slowly. In a few instances enormous sizes have been described. Reported cases range in age from 4 years to 65 years. Thompson (Kelly and Burnam), had a case the size of a cherry attached to the anterior urethral wall at about the mid portion of the urethra. There was no pain.

A case of Lornberg quoted by Kelly and Burnam was of a woman 31 years old. She had a tumor the size of a hazelnut just inside the dilated urethral orifice. It bled considerably and was painful. The same authors quoted a case from Büttner of a child four years old in which there was a tumor the size of a hen's egg projecting from vulva. It arose from the upper part of the urethra, and the external urethral orifice was converted into a slit 4 or 5 cm. broad.

Scholl and Braasch[72] quote Hönig's case in which a fibromyoma was 30 cm. in diameter, and connected with the urethra by a long pedicle. A case each of Wetherhill and Lobhardt was also cited. The former was a fibromyoma of 20 years duration which the patient complained of only because it had grown so large that it interfered with walking. The latter was a calcified tumor. Their own case was a fibromyoma, which had been growing slowly for twelve months. It caused spattering of urine and often blood after straining. It was red and 3 cm. in diameter.

Treatment. Sessile tumors of this type hull out easily and no further procedure is necessary. The pedunculated type need only ligation and severence of pedicle. They do not recur.

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* Kelly and Burnam.

POLYPI

Urethral polypi have been spoken of "as a rare growth at any point in the urethra causing symptoms of obstruction, or otherwise composed of epithelium and underlying tissues." * Fig. 18. Kreutzman[41] says that polypi are the result of long standing continued irritation to the mucosa, usually bacterial in origin, and that one need not expect to find them except in chronically infected cases. Fig. 17. He says "They are a sign post pointing to trouble somewhere along the line." † 87½% of his cases showed urinary pathology as follows:

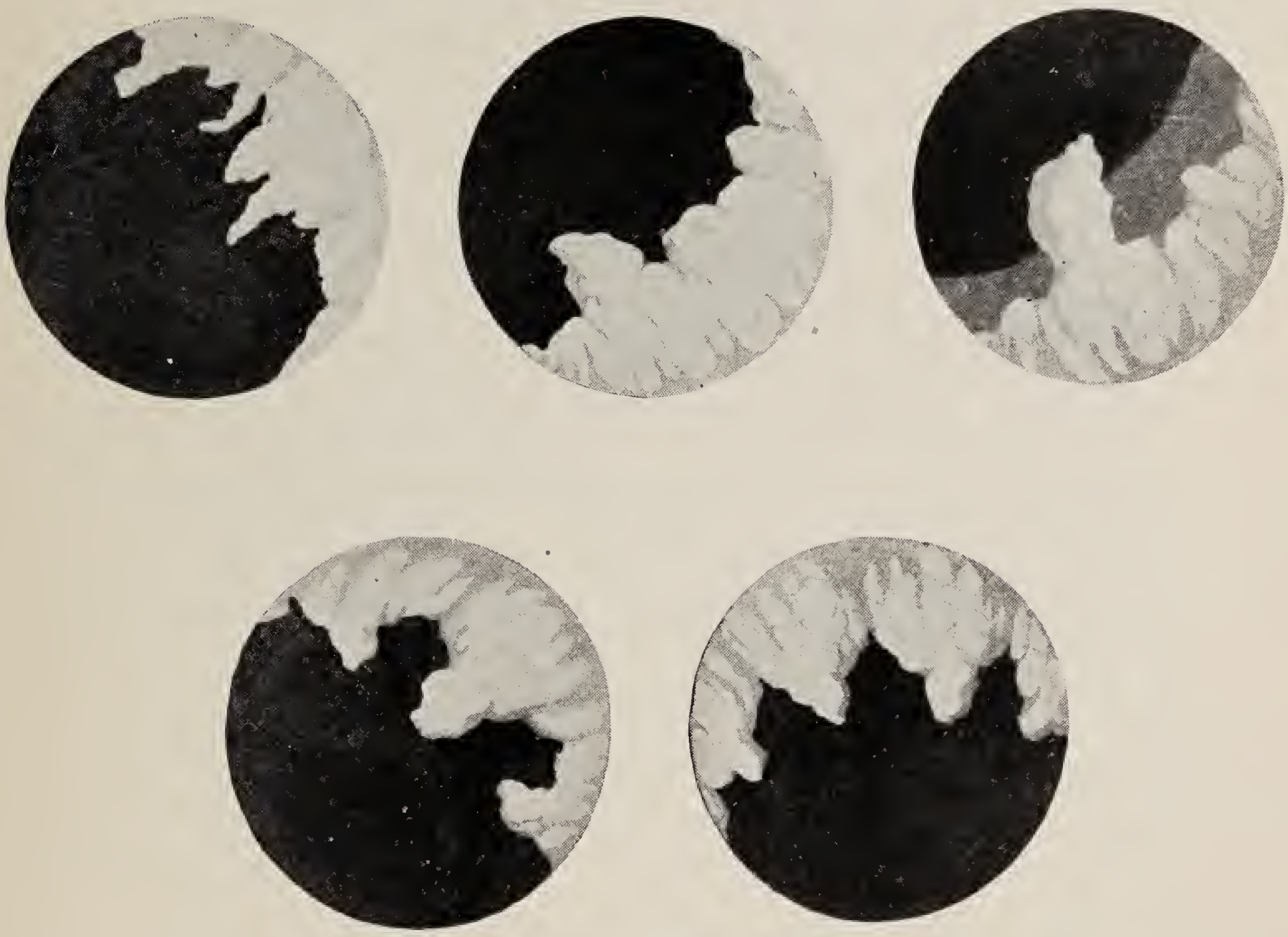

FIG. 17. Urethral Polyp (after Kreutzman).

Cystitis (including pyelitis 7%)	50%
Stricture of ureter	15%
Stricture of urethra	8%
G. C. Chronic	7½%
Renal Calculi	7%

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* Kelly and Burnam.

† Kreutzman: Papilloma of the female urethra. Surg. Gyn. and Ob., 38; 475.

In his opinion he either failed to make a correct diagnosis in the other 12½% or the pathology had cleared up before the patients were seen by him.

Polypi may occur anywhere in the urethra. Bullock, in 1893, reported a case in which the polyp was hanging from the meatus. Desqueim in 1895, reported one which was fastened to the right side of the urethra and resembled an inverted uterus. A second growth was found higher up in the urethra. H. M. N. Wynne[105] reported one found attached to posterior urethral wall ½ cm. above external meatus. It measured 10 × 6 × 3 mm. and had a pedicle 1 cm. long. Seven years previous to this the woman had been treated for a severe cystitis.

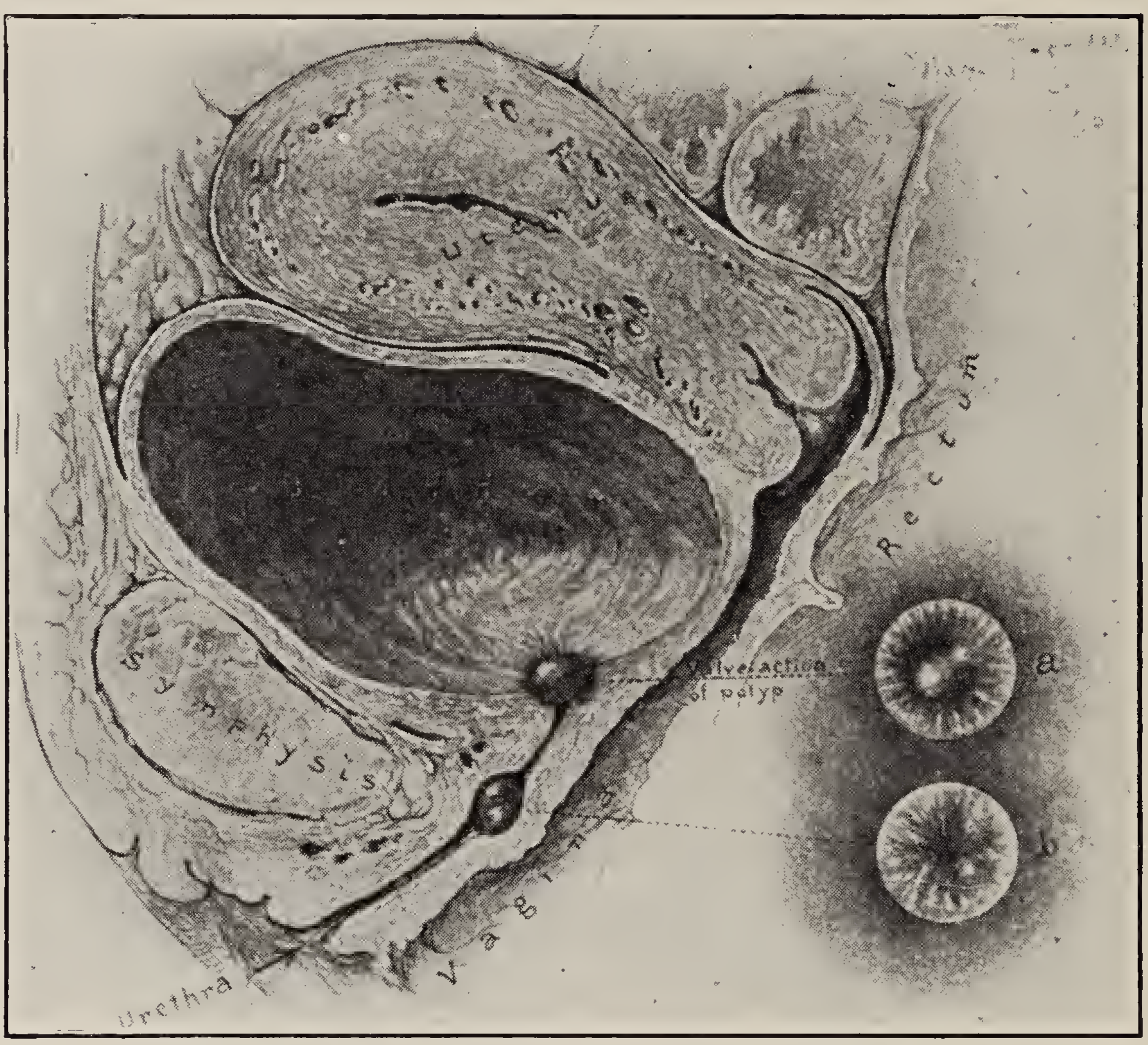

FIG. 18. Urethral Polyp (after Kelly and Burnam).

Symptoms. The most common symptoms are difficulty, frequency, nocturia, urgency, dysuria, and sense of fullness in the urethra.

Case report: Mrs. M. A. P., a nullipara 44 years of age, referred by Dr. Y. W. Haley, complained of frequency and dysuria and inability to get rid of a continual fullness in the region of the urethra. She had noticed that voiding was increasingly difficult for the past three or four years. She was cystoscoped and polyps found just external to the bladder sphincter as shown in figure 19.

The patient had visited many physicians hoping to find one who agreed with her in her own diagnosis. She steadfastly maintained that her "womb had fallen". She said she only had urinary symptoms when her cervix was protruding from the vagina. I could never prove that such a thing happened. After repeated examinations she was requested to remain quiet at home and call me the next time she found the cervix protruding from the vagina. In a very few days her husband called and said that she was having another attack and wanted me to come out and see for myself that the neck of the womb was sticking out the vagina. A hurried call resulted the same as on previous occasions. She explained that the womb had just gone back up.

She refused treatment for urethral polypi and insisted on having either a hysterectomy or a suspension. She added that she had already secured a surgeon for one or the other of these operations.

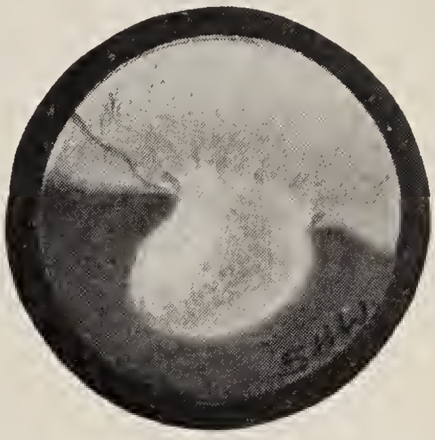
FIG. 19. Urethral Polyp.

A gynecologist was called in who had examined her six months previously with negative findings. He repeated his examination and said that there might possibly be some enlargement of the uterus. He insisted that she have the urethral polypi removed first. This was done a few days later by electro-coagulation. In another week she admitted that she was free of all symptoms except a bearing down in the pelvis.

One month after this the patient was still complaining only of a bearing down feeling in the pelvis.

The gynecologist operated and found numerous small intramural fibroids. He did a hysterectomy. The patient is not entirely cured, but she cannot point out any definite symptoms. She complains that at times she is "all in". She cannot make any more definite explanation of her condition.

Removal of urethral polypi is best done by electro-coagulation of the smaller ones. Larger polypi should be snared and their base coagulated. Patients should be examined for recurrence two or three times at six months intervals.

CARUNCLE

Caruncle. Charles Mansfield Clark[14] (1821) described caruncle, which arises from the region of the meatus; "The texture of this tumor is seldom firm; it is of a florid scarlet color, resembling arterial blood, and if violence is offered to it, blood of the same color is effused; its surface is somewhat granular."* He further described it as being exquisitely tender to touch, and appearing to shoot from the side of the urethra. James Paget[58] (1854) says that caruncles are quite frequent.

* Clark, C. M.: Observations of those diseases of the female urethra which are attended by discharge (Pages 295–299, Vol. 1, 1826).

Morgagni[50] first described the condition. Pomeroy and Milwood[61] describe it as a highly vascular benign growth, frequently located on a portion of the circumference of the meatus. Winckel[102] called it a " Papillary, polypoid angioma", and described the size as being between that of a pea and a hazelnut. They are usually located posteriorly on the meatus.

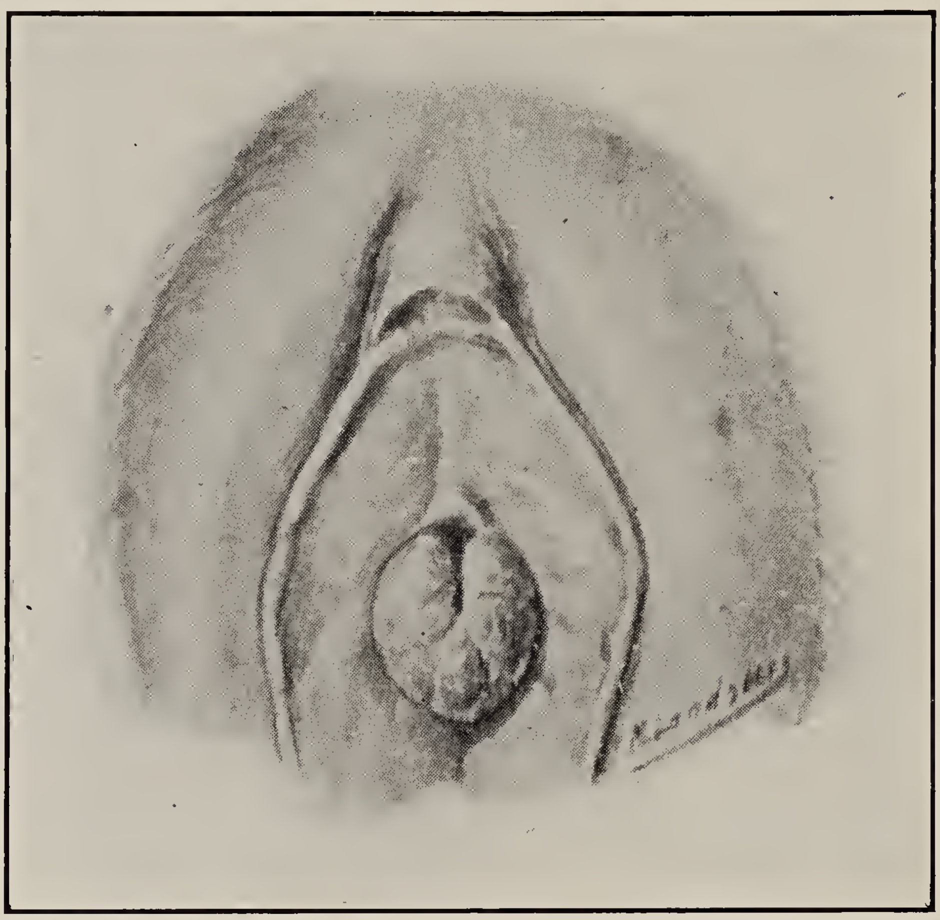

Fig. 20. Caruncle of Female Urethra (after Lowsley and Kirwin).

Charles Mansfield Clarke[14] (1821) reported 3 cases. Morgagni[50] said that the condition was more common than stricture. According to Pugh (1929)[69] it is moderately common, occurring at all ages. He quotes:

Ferrier as finding a case at 6 years age
Stevens " " " " " 67 " "
Another on record as being 90 " "

Clarke states that it is a disease common to both single and married women, usually below middle life.

James Paget[58] (1854) said that the growth consists of abundant and " tasselated " epithelium covering a small amount of muscle tissue with many close-set and looped blood vessels. Pomeroy and Milwood[63] (1925) quoted Otis Graves as saying that a true caruncle is covered with squamous epithelium, characteristic of the vestibule. As a means of differentiating it from prolapse of the urethra, he says that in the latter condition the prolapsed mucosa is covered by modified epithelium characteristic of the urinary tract. Writers mention that despite the extreme sensitiveness of the growth, no nervous tissues can be demonstrated in it. Pugh (1929) says that caruncle consists of tufts of capillaries in a fibrous and muscular stroma, with many mononuclear and polynuclear cells. He says that few nerve elements have been demonstrated in them, except in the squamous epithelium. He quotes Young as believing them malignant, and as reporting five definitely so. Recurrences are rather frequent.

As to the cause of the caruncle, Richard R. Smith[78] (1920) suspects prolapse of the urethra and cystocele. Pugh (1929) says that the cause is obscure, that some connect it with Skenitis, and that Neuberger believes it due to old gonorrhea. He is reasonably certain that long-continued irritation does play a part.

Sir Henry Thompson[88] (1869) called attention to the fact that caruncle is extremely sensitive to pressure or other stimuli. H. H. Bubgee[10] (1917) mentions frequency of urination as a symptom, and reports 691 urological patients presenting the symptom of frequency;

In	4th	decade	2	out	of	315	had	caruncle
"	5th	"	3	"	"	222	"	"
"	6th	"	4	"	"	101	"	"
"	7th	"	2	"	"	53	"	"

Kelly and Burnam (1922) state that a caruncle bleeds easily, and that urination and coitus may cause excruciating agony. Pugh (1929) writes that it may be small but cause a lot of misery, and that it causes urgency, frequency, bleeding, and rectal and vesical tenesmus, plus many nervous and constitutional symptoms. On the other hand, many are unaware of its presence.

Treatment of caruncle. In 1811 Clarke[14] advised excision of the caruncle with scissors followed by the cautery. Sir Henry Thompson advised the same treatment in 1869. Emmet[19] (1879) advised ligature and excision. Pomeroy and Milwood[63] (1925) reported no recurrence after treatment with screened radium. They used the application of screened radium to the urethral canal, 50 mg. of radium element screened with 0.5 mm. of silver, 1 mm. brass, and 1 mm. rubber, and the insertion of enough 5 mg. steel needles to occupy the growth, and usually to surround the urethral canal. They allowed the radium to remain in place from three to six hours and they thought one treatment was sufficient. Pugh (1929) advises eradication by cauterization, ligation, snaring, and excision.

Perhaps, after all, it is only the judgment of the surgeon in charge which can determine whether a condition is caruncle, eversion of the urethra or new growth. In either caruncle or eversion the presence of cystocele is of importance. If a marked cystocele is present it should be repaired. Such repair may relieve eversion, and occasionally it has been said to have relieved the caruncle. Where caruncle is to be treated directly it is perhaps best to resect the caruncle under general anæsthesia and stitch the mucosal edges with fine catgut. Too many cases do not get anæsthesia when caudal and sacral anæsthesia is attempted, while local anæsthesia is out of the question because it distorts the tissues beyond recognition.

The use of the electro-cautery is questionable because coagulation tissue in the field of operation is misleading. Too extensive coagulation will result in a hard stricture which will be difficult to dilate. Radium treatment and snaring have not come into general use and it is perhaps safe to regard them as being more dangerous than the procedure outlined above.

ANGIOMA

Scholl, Jr. and Braasch (1922) state that only a few cases of angiomata have been reported, and that they bleed freely, cause little pain, and usually respond readily to fulgeration. They may even be pedunculated.

RETENTION CYSTS

Retention cysts have been reported but are extremely rare. They, of course, arise from the glands of the urethra. Winckel[102] says that they have been found in the 6 months fetus, and that they do not always project above the surface. They may attain a larger size, and protrude as large round tumors from the urethra. They may be covered with normal mucus membrane. They may be polypoid.

CONDYLLOMA

Condyllomata, according to Winckel, have warty surfaces, are red, pedunculated, not sensitive, rarely bleed freely, and may be single or multiple about the orifice. They consist of a fibrous or homogeneous connective tissue, a capillary network, and a thin epithelial covering. They are to be differentiated from caruncle, and other tumors about the orifice.

Other tumors of the female urethra occur but are of such rarety that a mere mention of them suffices.

URETHROCELE

Urethrocele of the female urethra is that condition in which the urethra or its mucous membrane is prolapsed through the external urinary meatus, properly called a urethral prolapse; or a sacculation in the course of the urethral canal, usually accompanied by a cystocele.

History. John Baptist Morgagni[50] (1824) wrote of the prolapse of the female urethra and described cases. Thomas Addis Emmet[19] (1897) described the condition also, and listed it as one of the important lesions of the female urethra. In 1890 Ely Van der Warker[92] wrote of prolapse as simply a form of stricture. From this time on we find many writers describing the condition. Among these are John W. Keefe[37] (1917), Richard R. Smith[77] (1920), Thomas N. Hepburn[29] (1920), George R. Livermore[44] (1921), Kelly and Burnam[39] (1922), Gilbert J. Thomas[87] (1923), Arthur L. Chute[13] (1925), Adolph Jacoby[31] (1925), Thomas J. Watkins[97] (1925) and many others. The condition is recognized as a comparatively rare one, but not so rare, however, as formerly thought. Since the time of Morgagni it has come to be known as an important condition to be diagnosed and treated.

Incidence. According to John Keefe[37] (1917):

60% of urethroceles are in children.
12% of urethroceles are in adults 15 to 40 years of age.
28% " " " " " over 40 years of age.

He states that the youngest case reported is in a child five days old, and the oldest in a woman 92 years old. He says that it is a condition found especially in debilitated children and old people.

Pathology. Thomas Addis Emmet[18] (1882) stated that urethrocele is but a condition where a greater degree of thickening has followed the overstretching of the urethral tissues with laceration of its wall, and leaving a pouch behind for the stagnation of a certain amount of urine, which adds to the irritation. Ely Van der Warker[92] (1890) described the condition as a type of stricture, explaining that there was an annular stricture at the meatus with a subsequent dilatation behind it.

Richard R. Smith[77] (1920) describes urethrocele as being an open meatus, exposing the tender mucosa and that during straining discloses a rolling, bulging edema of the structures there. He says that an urethrocele can not develop as long as the uterus lies in its normal axis, but that there is first a dropping downward and forward of the cervix, relaxing and permitting pouching of the anterior vaginal wall with the development of a cystocele. Thomas N. Hepburn[29] (1920) described it as a herniation of the urethra due to straining. Kelly and Burnam described the pathology of urethrocele as being much like that of hæmorrhoids, showing distorted blood vessels and blood clots. At any rate, to inspection an urethrocele presents the appearance of an everted mucosa.

Etiology. John W. Keefe[37] (1917) gave a list of causative agents which included the following: cough, constipation, straining at stool, trauma, cystitis, vesical tenesmus, stone in the bladder, parturition, angioma, and general debility. But he adds that he thinks that the real cause is neuromuscular, and that the nerve mechanism that controls the detrusor urinæ muscle loses its normal balance, and exerts too great a force on the normally loosely attached mucous membrane of the urethra, producing an extrusion of its membrane: consequently the constrictor muscle of the urethra becomes partially paralyzed. Hepburn[29] (1920) attributed prolapse to straining, and said that it was especially prone to occur in persons with congenitally poor structures. Kelly and Burnam (1922) mention thrombosis due to constriction of the vessels there, and states the prolapse may develop suddenly due to such causes as a blow on the abdomen, rape, a long-standing diarrhea, or violent coughing. Thos. J. Watkins[97] believes that atrophy affects the vaginal mucosa more than the urethral mucosa after menopause, thus tending to cause prolapse of the urethral mucosa. Herman J. Baldt expresses the same belief, except that he thinks that the urethral muscularis and the submucosa also take part in this increased atrophy. Bonney,[6] in his book, says that urethrocele is a relaxed condition of the urethra, from such causes as quickly repeated labors, rapid dilatation of the urethra by foreign bodies, passage of calculi, masturbation, straining at stool, strangury, etc.

Symptoms. Prolapse may be the source of much pain and suffering. Thomas Addis Emmet[19] thought that if such a condition remained long without relief cystitis was inevitable. Keefe[37] (1917) says that the condition may be merely noticed or there may be continuous pain with vesical tenesmus, and that ulceration and gangrene with sloughing might occur. There is usually frequent and painful urination, with more or less constant discomfort in the region of the bladder and the urethra. There is frequently marked tenderness locally. Hepburn[29] (1920) says that chafing of clothes on the vulva causes the chief complaint. George R. Livermore[44] (1921) reports a case which had a completely prolapsed urethra, accompanied by pain, frequency, tenesmus, passage of bloody urine, marked tenderness, and a serosanguinous discharge from the urethra. Kelly and Burnam mention that there may be straining and dribbling. Bonney adds that incontinence may result. Where there is a sacculation in the course of the canal the sack usually becomes infected and filled with pus. There is then a purulent discharge from the urethra accompanied by a tender area on the anterior vaginal wall. Pressure on the tender area will frequently expel the contents of the sac through the meatus, upon which the patient may feel relieved of discomfort.

Diagnosis is made upon the above symptoms and a physical examination which reveals tender partial or complete tumorlike eversion of the urethral mucosa. Or a sacculation may be palpated through the anterior vaginal wall, hard if there is a narrow connection with the urethra, and soft and compressible if there is a wide connection.

Treatment. Emmet in 1879 advised that, in treatment of these cases, a button hole slit to be made in the urethra, the loose tissues drawn back from the meatus, secured in the edges, the excess cut off, and the opening closed. He claimed to get permanent cure with this procedure. Keefe[37] (1917) advocated exposure and tightening of the external sphincter muscle of the urethra, claiming to get no recurrence. Richard Smith[77] recommended that the perineum be repaired so as to hold the cervix back into place. Thomas N. Hepburn[29] (1920) in a 5-year old patient went in through a suprapubic incision, loosened up the tissues in the prevesical space, reduced the prolapse by traction on the bladder, and sutured the neck of the bladder to the periosteum of the pubic bone, with #2 chromic catgut. In his postoperative care he was careful to have the patient void frequently to avoid strain on the sutures before adhesions formed. He claims good results.

Kelly and Burnam advise radical surgery, by removal of the prolapsed part, suturing the mucous membrane to the meatus. They think that some cases, however, can be cured by rest in bed with the application of astringents. Emmet entered through the vaginal mucosa, grasped the urethra, reduced the prolapse by traction, and fixed it in position with sutures. Dr. Dougal Bissell, in three cases of long standing, operated, using the Whitehead hemorrhoid method. Adolph Jacoby[31] (1925) excised the prolapsed portion, and approximated the cut edges with interrupted sutures, and got a complete recovery in two months, other methods such as astringents, attempted reduction, and rest, having failed. Watkins[97] (1925) used a method whereby he shortened the mucosa of the urethra enough to reduce the prolapse and sutured it.

Smith, while emphasizing the importance of correcting the usually accompanying cystocele and uterine misplacements, believes it is also important to recognize and correct the local urethral condition which is often overlooked unless the patient is asked to bear down as if voiding.

He describes in detail his operation for correcting the prolapse. He advises removing the protruding mucosa or frequently found caruncle. He closes the meatus to its normal dimensions by carefully denuding a little of the surface of the circumference of the meatus and placing fine chromicised sutures as in Fig. 21 a. Then he denudes a large triangular surface of the protruding anterior vaginal wall, the base of which is placed as high or slightly higher than the lower edge of the pubic bone, so that closing of the sutures will draw the meatus to the proper position, as in Fig. 21 b. These stitches, which are of chromic catgut, must avoid the urethra and are placed deeply enough to anchor the sutures to the deep tissues close to the pelvic bone. If an ordinary cystocele operation is performed he makes his median incision along the anterior vaginal wall, as is usual, continuing it well forward, then breaking it by a transverse one (Fig. 21 c) which forms the base of the triangle shown in Fig. 21 a and finishing the operation as above. When an interposition operation is

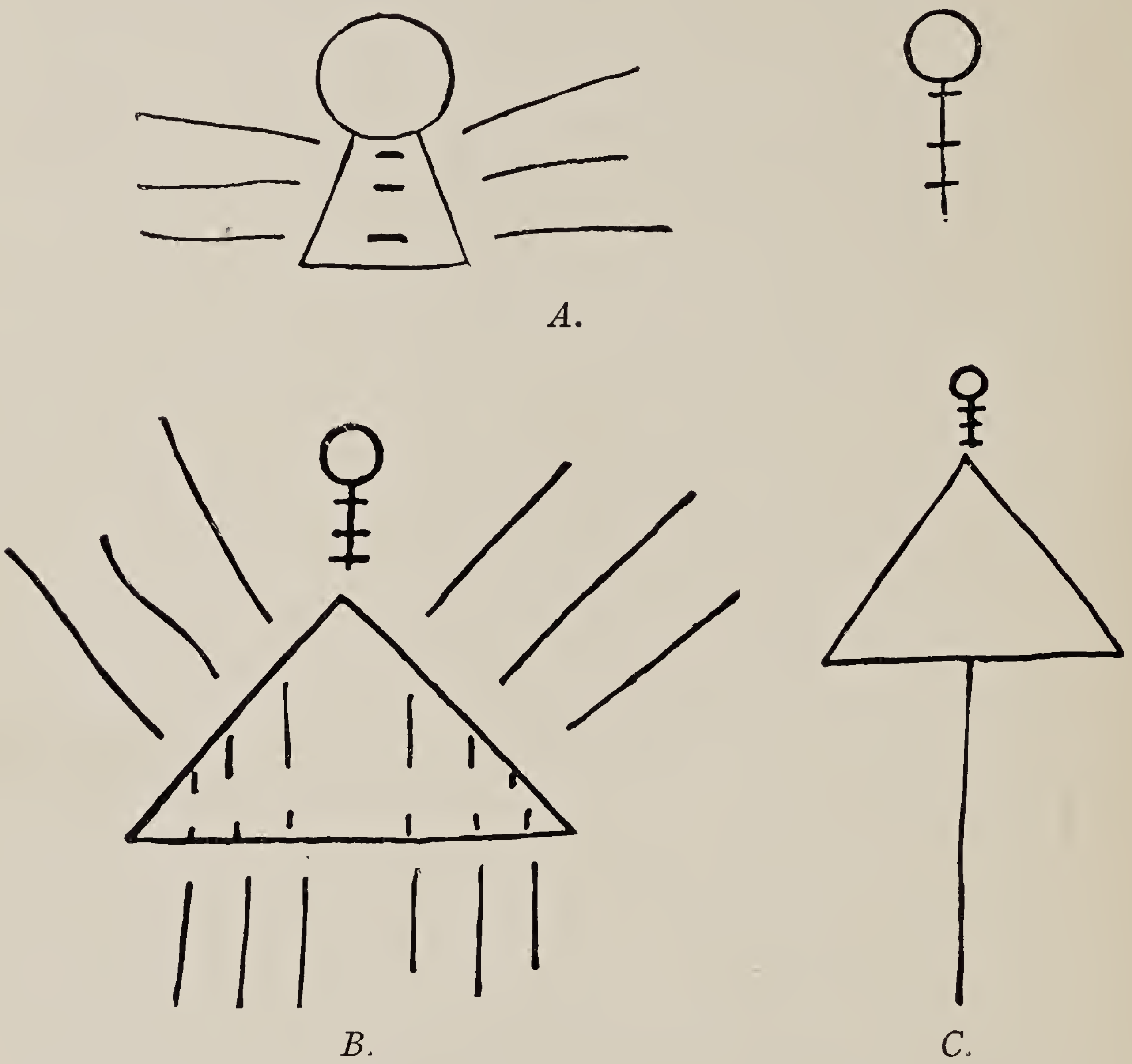

Fig. 21–*a*. Diagram of operation for prolapse on meatus itself (after Smith).

Fig 21–*b*. Operation for Prolapse. Denudation and suturing of the anterior vaginal wall above the meatus (after Smith).

Fig. 21–*c*. Operation for Prolapse. Lines of incision used when other operations are performed requiring the usual longitudinal incision in the vaginal wall (after Smith).

performed, he advises bringing the fundus close to the pubis and stitching it firmly there, placing the retaining stitch directly on top of the fundus. He reports good results with this operation and has had no trouble with recurrences since adopting this method.

Fig. 21 a. Diagram of operation for prolapse on meatus itself. This is done for the purpose of narrowing a dilated orifice and restoring normal protection to the urethral mucous membrane. (After Richard Smith).

Smith, Richard R. Prolapse of the Female Urethra. — Jour. Am. Med. Assoc., **74:** 1639 June 20, 1920. Fig. 1.

Fig. 21 b. Denudation and suturing of anterior vaginal wall above meatus. After obtaining a good hold on the forward edge of the mucous membrane, a rather deep bite is taken into the firm tissue beneath the pubic bone, care being taken of course to avoid the urethra. When tied the meatus is drawn upward and its normal protected position restored. (After Richard Smith).

Smith, Richard R. Prolapse of the Female Urethra. Jour. Am. Med. Assoc.. **74:** 1639, June 20, 1920. Fig. 2.

Fig. 21 c. Lines of incision used when other operations are performed requiring the usual longitudinal incision in the anterior vaginal wall. (Courtesy of Jour. Am. Med. Assoc., publishers).

Smith, Richard R. Prolapse of the Female Urethra. Jour. Am. Med. Assoc., **74:** 1639, June 20, 1920. Fig. 3.

DIVERTICULA

Diverticula in the female are rare and may be congenital or acquired. Congenital diverticula have been discussed under congenital anomalies. Acquired diverticuli are similar, and are hard to differentiate from the congenital. When acquired they are usually the result of injury, particularly during childbirth. For pathology, symptoms and treatment, see the discussion under congenital diverticuli.

FOREIGN BODIES

Rather infrequently the presence of foreign bodies in the female urethra becomes of clinical interest. These foreign bodies may come into the urethra at either end. Not infrequently stones from the kidney gain their entrance to the urethra and usually pass quickly to the outside, but may become impacted there and cause much trouble. It is quite a common thing for masturbators to introduce foreign bodies into the urethra and occasionally these objects may become lodged in the urethra. Morgagni[50] tells of a stone that formed on a bodkin that had been inserted through the urethra and which was blocking it, producing death in a 14-year old girl. He tells of another case in which a girl pushed a bodkin into the urethra and through the anterior vaginal wall, causing it to protrude into the vagina, where a concretion formed on it.

Walter S. Pugh[69] (1929) states that urethral stone is rare indeed, the structure of the urethra being such as to tend toward dislodgement. He says that in childhood it is often due to the introduction of foreign bodies and their subsequent incrustation with lime salts. He found a well encrusted lead pencil rubber in a girl of 13 years of age, and removed it. In this case the incrustation consisted of uric acid and calcium oxalate. She had a constant desire to urinate and presented a thick yellowish-white discharge from the urethra.

Lowsley & Kirwin (1926) found only 20 cases in the literature of which that of Halban reported in 1900 was the best known. This was an aged woman in whom an operation disclosed 5 urethral stones and a number of vesical calculi.

The Brooklyn Hospital (1927) reported a case of a woman in which there was pain dating from the passage of a small stone. This pain was in the lower part of her back on the left side, and was almost constant, becoming more severe at intervals of 2–7 days. She had some discomfort on urination and some frequency. X-ray examination showed a small shadow over the symphysis, to which no significance was attached. The patient was seen one year later, when she came in complaining of dysuria, frequency, pain in the bladder region, and leucorrhea. X-ray examination revealed a bilateral hydronephrosis. When the endoscope was inserted for an examination, it brought a gush of thick creamy pus, and the instrument was felt to grate against something. Under sacral anesthesia two stones were crushed and removed from the urethra. Following this her symptoms, including her leucorrhea, cleared up.

In removing the foreign body it is well to put a finger in the vagina, while an instrument is introduced through the urethra. The procedure may required local or sacral anesthesia.

CONCLUSION

The female urethra is becoming recognized as an increasingly important cause of genito urinary and neurotic symptoms in which occurs pathology similar to that occurring in the male urethra. Embryologically and anatomically it is the homologue of the middle portion or true urethra of the male. In recent years its anatomy and embryology have been comparatively carefully worked out and demonstrated. The history and results of these investigations and conclusions are set forth in this paper. The literature on this subject has become voluminous and is fairly completely listed in our bibliography.

The examination of the female urethra, although somewhat simpler is quite as important as that of the male. The pathology occurring in the female urethra is essentially analogous to that occurring in the male urethra, more particularly to that in the middle or true portion.

Congenital anomalies, infection and inflammation, stricture, new growths, urethrocele and foreign bodies are all found in the female urethra although their occurrence is more rare as would be expected from the shortness of the canal. Symptoms may be mild but are often severe and varied. In many instances they correspond closely to those of the male. Frequently they are ignored and endured under the diagnosis of "Female trouble." Treatment is important and is often attended by marked and salubrious results.

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